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ULTRA-SHORT (MILLISECOND) TIMING IN ROENTGEN DIAGNOSTIC PROCEDURES INCLUDING ANGIOCARDIOGRAPHY: COMPARISON OF DYNAPULSE AND IMPULSE TIMING*

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DURING the past two years a new electronic switching system capable of roentgenographic exposures of 1/1000 second has been used in the Germantown Hospital to evaluate its usefulness in angiocardiography and other diagnostic procedures, and to compare its results with those obtained with an impulse timer engineered to operate reliably at 1/120 second. The photographically effective portion of these impulsed timed exposures is of the order of 1/200 second. Therefore, the new or dynapulse timer is five times faster. Dynapulse exposures are produced by a controlled electron flow vacuum tube in the high tension or secondary circuit of a roentgen-ray generator with four valve tube rectification and a filter condensor across its output. Power from the condensor is thus released to the roentgen-ray tube by this timer. The range of the dynapulse timer used by us varies from 1/2000 second to five milliseconds. The shortest exposure advocated by the manufacturer is 1/1000 second. Dotter advocated such ultra-short times to stop motion in angiocardiography and these undoubtedly eliminate movement blurring.[1] Wegelius and Lind[3] stated that the maximal tolerable exposure in angiocardiography in infants was .02–.04 second depending on heart rates. Kjellberg, *et al.*,[2] using a three phase generator with a thyratron contactor, obtained excellent angiocardiograms at exposure times of .003 seconds in infants and .03 to .045 seconds in adults.

In order to determine whether there is a recognizable difference in roentgenograms obtained with dynapulse and impulse timing, several comparative studies were done. An experiment comparing roentgenography of a fine wire mesh on a spinning disk

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driven by a synchronous motor of known speed permits critical comparison of the unsharpness produced by motion with the two timing methods. It should be noted that this is a very severe test, since the fine wire mesh presents greater detail than one would expect to encounter in the analysis of lung or angiocardiographic roentgenograms and is more comparable to fine trabecular detail of bone. The speed in centimeters per second of the circular path where unsharpness of the mesh is grossly eliminated is readily determined by multiplying the known speed of the disk in revolutions per second by the circumference of the circle in centimeters. By this method, motion of about 80 cm. per second is "stopped" by a millisecond exposure and 20 cm. per second by 1/120 second. This finding is thought to be important in angiocardiographic procedures, since the maximal rate of blood flow in man is estimated to approach 100 cm. per second.

A comparison of chest roentgenograms of children made with a dynapulse timer at 1/1000 second and impulse timers with exposures of 1/120 and 1/60 seconds was carried out. The group studied varied in age from three months to fourteen years. The films were analyzed by four observers independently, and without knowledge of identity of the dynapulse films. We were unable to detect any difference in detail of pulmonary markings on films made with the two timing methods in either normal or diseased lung (Fig. 1). Thus, conventional timing seems as valuable as the dynapulse timer in eliminating motion due to pulsation of pulmonary vessels. Dynapulse timing necessitates the use of at least a 2 mm. focal spot. Roentgenograms exposed with conventional timing using similar and lower kilovoltages and 1 and 2 mm. focal spots, respectively, were used in the above comparison with the dynapulse roentgenograms without detectible difference in unsharpness.

Our studies to date show good technical results in angiocardiography when dynapulse timing is used in conjunction with a rapid film changer.* The latter moves 14 inch wide roll film at an average speed of four 11 inch segments per second. The top speed of the changer is six films per second, but its best performance is at slower speeds. The changer is controlled by an electronic programmer that permits preselection of the following: the number of films per second, interval between exposures and the total number of films. Thus, intelligent planning prior to the beginning of the film run makes it possible to obtain maximal information with the least possible exposure to the patient.

The claim has been made that septal defects, shunts and heart valve abnormalities might be better portrayed roentgenographically when millisecond timing is used because the flow of contrast is "stopped" by ultra-short exposures. An attempt to compare dynapulse and impulse timed angiocardiograms of the same child did not seem justified in view of the necessity of multiple injections and exposures. Therefore, studies were done on dogs, using the two timing methods but with other factors being the same, including the anesthetic, pulse rate, concentration and volume of contrast medium, injection time and film processing. Venous angiocardiograms obtained at 1/120 and 1/1000 seconds were of excellent quality, and there was no appreciable difference in their sharpness (Fig. 2 and 3). The pulmonary, mitral and aortic valves, muscular trabeculae, coronary arteries and great vessels with their branches, including the internal mammaries were equally well visualized by both timing methods (Fig. 2 and 3). The pulmonary and aortic valves were demonstrated in their open and closed positions and the sinuses of Valsalva were clearly delineated.

Left-sided angiocardiograms following injection of opaque contrast material into the left ventricle were also carried out with no appreciable difference between the two timing methods. Dilution of the opaque

* Rapid film changer developed by Franklin X-ray Corporation, Philadelphia 43, Pennsylvania.

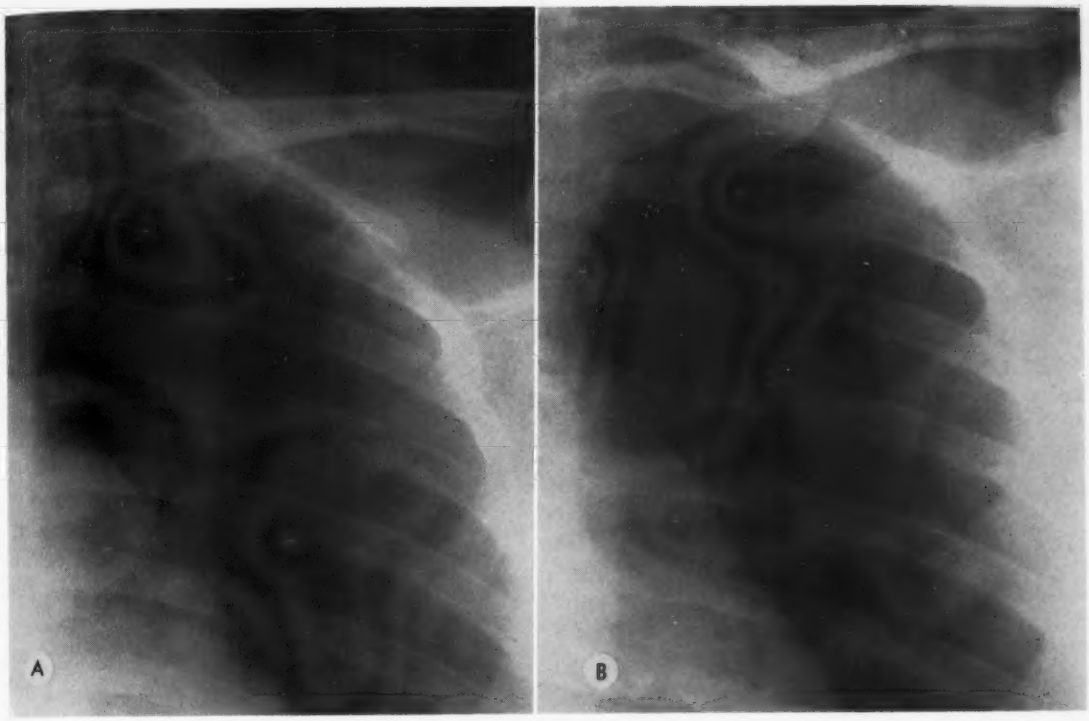

FIG. 1. Detail of pulmonary markings not superior on 1/1000 second exposure (*A*) to that demonstrated on 1/60 second impulse timed film (*B*).

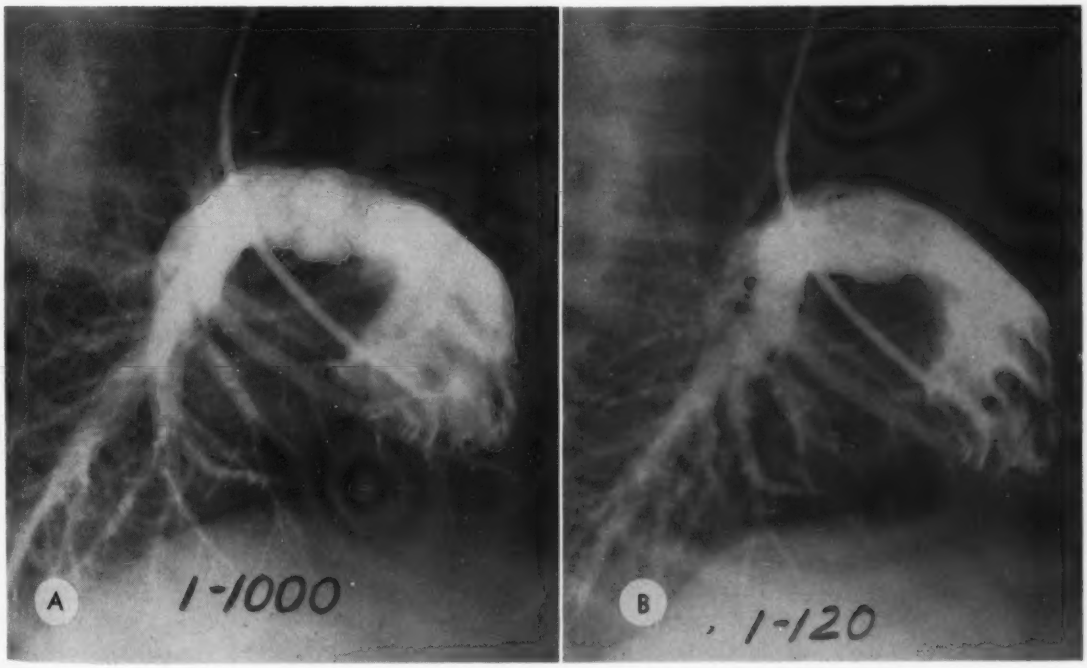

FIG. 2. (*A* and *B*) Comparison of 1/1000 second dynapulse and 1/120 second impulse timed venous angiocardiogram of a dog reveals equally sharp definition of muscular trabeculae of right ventricle, pulmonary valve leaflets and pulmonary artery and its branches.

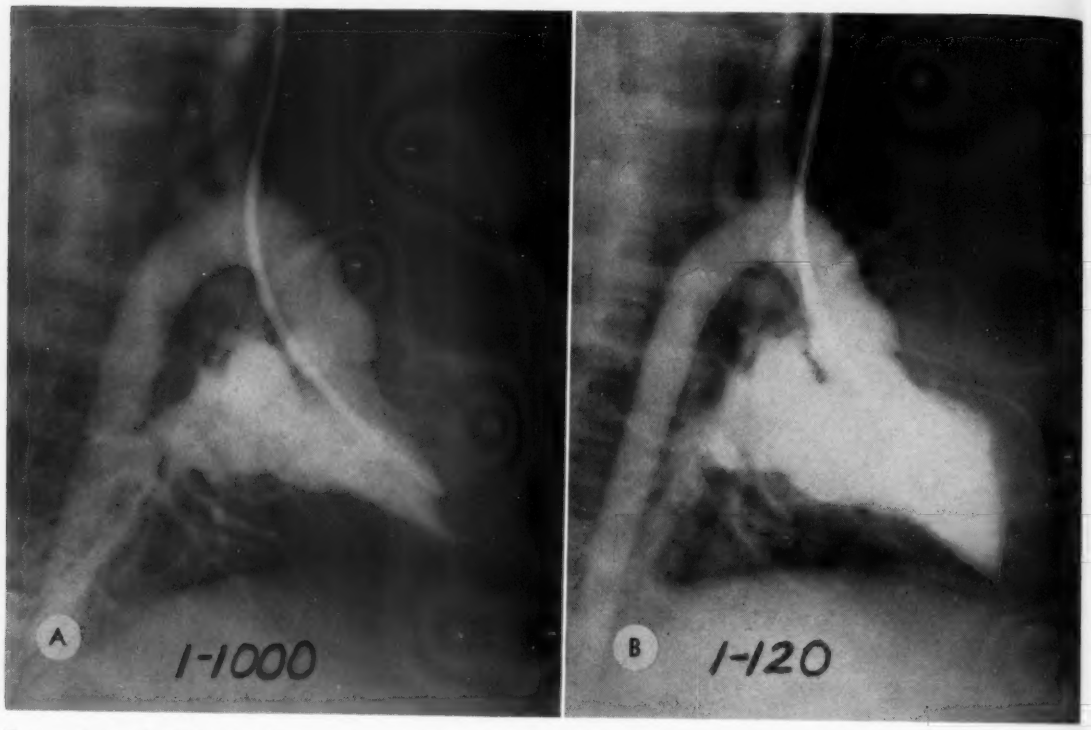

FIG. 3. (*A* and *B*) Left atrium and ventricle, aortic and mitral valves, coronary and internal mammary arteries and aorta with its principal branches are equally well portrayed by millisecond and 1/120 second impulse timed angiocardiograms of a dog following injection into right ventricle.

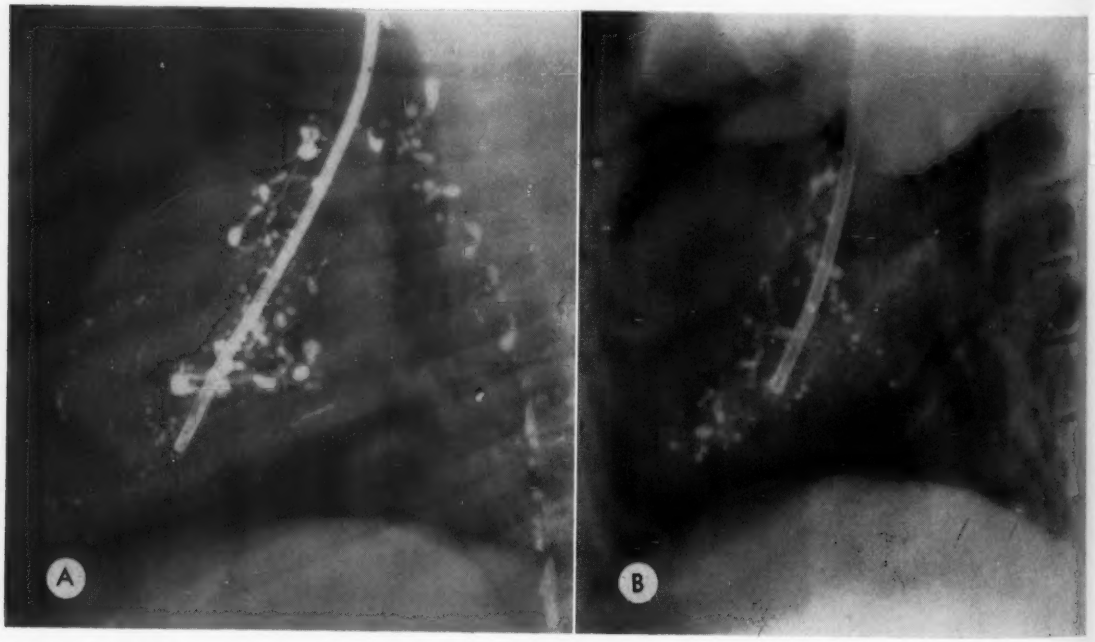

FIG. 4. (*A*) Millisecond exposure "stopped" rapidly moving droplets of iodochloral in left ventricle and proximal aorta of a dog after injection into ventricle through a catheter. (*B*) Note blurred droplets in same areas on 1/120 second exposure.

contrast material in the left ventricle by influx of nonopacified atrial blood was equally well visualized by both methods. This phenomenon can be considered a physiologic "jet," comparable in many ways to what might occur as a result of a congenital defect. Future experiments on dogs with artificially produced intracardiac defects are planned to compare possible advantages of millisecond timing over impulse timing of 1/120 second or longer in the visualization of shunts.

A comparison of the relative effectiveness of millisecond and impulse timed exposures in stopping motion of particulate oil contrast material injected into the left ventricle of dogs through a catheter revealed the superiority of ultra-short exposures. Sharp definition of oil droplets was apparent throughout 1/1000 second films. In contrast, roentgenograms made at 1/120 second revealed blurring of opaque oil droplets in the proximal aorta at the moment of maximal propulsion (Fig. 4). This finding seems to have little practical value clinically since no safe opaque particulate contrast material is available, but it may find application in physiologic investigation. In clinical practice, we have used the dynapulse timer principally for cardiac and cerebral angiography and aortography. It is our belief that exposures as short as 1/1000 second are unnecessary for cerebral angiography and therefore usage of the dynapulse timer will depend on its availability.

Our experience with dynapulse timing in congenital heart disease is not extensive, but millisecond exposures in combination with the previously mentioned rapid film changer have resulted in angiocardiograms of excellent quality and sharpness. An unusually good demonstration of multiple congenital abnormalities was obtained in an infant with proved situs inversus, tetralogy of Fallot, an anomalous pulmonary vein and an interauricular defect. The latter two abnormalities were elicited by catheterization, but the component defects of the tetralogy, including the interventricular shunt, were well demonstrated.

Sharply defined angiocardiograms were also obtained with millisecond exposures in a twenty month old female with confirmed pulmonary stenosis. The right atrioventricular valve and pulmonary stenosis were well delineated (Fig. 5). On the other hand, an angiocardiogram of comparable technical quality was obtained of a seven month old female using a combination of 1/120 second impulse timing and the rapid serialograph. An anomalous origin of the right subclavian artery was clearly depicted. An interatrial de-

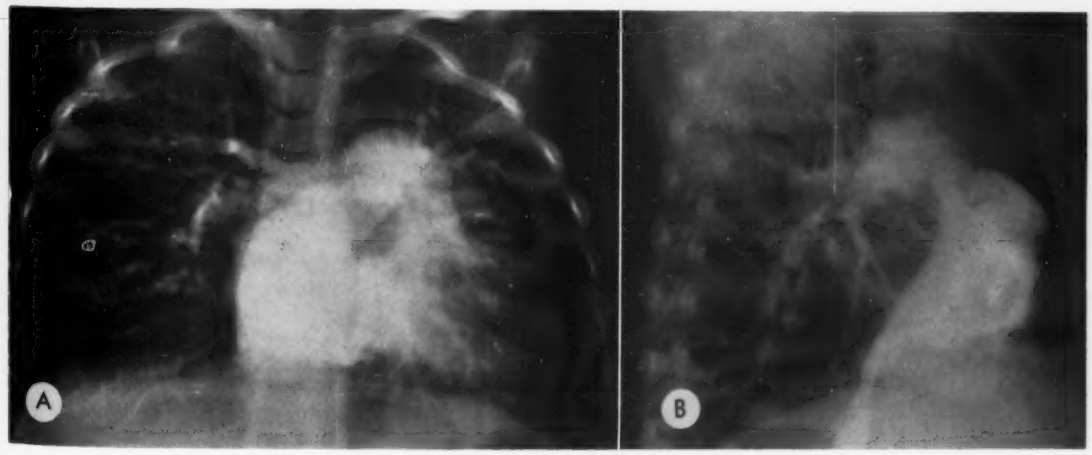

Fig. 5. (*A* and *B*) Infundibular stenosis and poststenotic dilatation of pulmonary artery, clearly revealed on 1/1000 second angiocardiograms of a twenty month old child following injection into the right atrium. Right atrioventricular valve visualized on *A*.

fect, proved by catheterization, was not revealed by this film study. The above studies and others in our clinical experience, while not revealing an appreciable difference in detail with dynapulse and 1/120 second impulse timing, are undoubtedly of superior quality to those obtained with slower conventional timing methods. It is our feeling that ultra-short exposures with resultant sharp detail do not obviate the need for rapid serialographic studies.

CONCLUSIONS

Experience with the dynapulse method of ultra-fast roentgen-ray timing, using a controlled electron flow vacuum tube in the high tension circuit has been compared with results of impulse timing. Exposures as short as 1/1000 second are of practical value for the production of sharp roentgenograms in pediatric roentgenography, and especially in angiocardiography. Experimentally, with a mechanical test object, millisecond exposures stopped motion of 80 cm. per second which approaches the estimated maximal rate of blood flow. Particulate contrast material moving at such speed in the proximal aorta of dogs was "stopped" by millisecond exposures. However, dynapulse timing revealed no diagnostic superiority over rapid impulse timing in pediatric chest roentgenography, in cerebral angiography and in angiocardiography in normal dogs.

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ANGIOCARDIOGRAPHIC FEATURES OF THE BLAND-WHITE-GARLAND SYNDROME*

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ANOMALOUS origin of the left coronary artery from the pulmonary artery has been recognized clinically with increasing frequency in recent years. The anomaly was described as early as 1906 by Konstantinowitsch[37] in a congenitally grossly malformed heart. Abrikossoff[2] gave the first classic description in 1911. The diagnosis in most of the reported cases has been established only post mortem. The anomaly was considered a pathologic curiosity until Bland, White, and Garland[7] reported characteristic electrocardiographic changes and clinical features in 1933.

In 1955, Paul and Robbins[48] reported the first successful poudrage operation with marked clinical improvement. The possibility of surgical benefit[25,49,64] for infants with this anomaly renders the early diagnosis of this condition imperative.

In studying 4 proved cases of this entity, a characteristic picture has been found on angiocardiography which promises to be a valuable adjunct in diagnosis. These cases are therefore reported in detail. In addition, the diagnostic features of 62 cases from the literature are summarized.

REPORT OF CASES

CASE 1. A.J.B., a white female infant, was first seen because of feeding difficulties at four months of age following an uneventful neonatal period. A first maternal cousin was known to have congenital heart disease. The exertion associated with feeding seemed to provoke rapid respirations and a peculiar arching of the head backwards—this was interpreted as a manifestation of chest pain.

Clinical Examination. The infant appeared thin, pale, and dyspneic. Respiratory grunts and subcostal retractions were noted. Although circumoral cyanosis was present, there was no cyanosis of the nail beds or clubbing. No cardiac murmurs were heard.

Electrocardiogram. There was evidence of a balanced axis, left ventricular strain, supraventricular tachycardia and signs of an old anterolateral infarct. The ST segments were elevated in Leads I, II, V_1, V_3R, and V_5. There were abnormal deep Q waves in Leads I, AVL, V_3, V_5, and V_6. Serial electrocardiograms showed essentially the same findings with subsequent inversion of T-waves in Leads I, II, V_3, V_5, and V_6.

Roentgen Examination. A chest roentgenogram showed a markedly enlarged heart with left ventricular preponderance (Fig. 1*A*). The lateral view showed posterior displacement of the barium-filled esophagus indicating left auricular enlargement (Fig. 1*B*). The pulmonary vascularity appeared to be slightly increased. An area of atelectasis was initially seen in the right upper lobe, and later in the lingula.

Angiocardiogram. The right chambers were normal in size (Fig. 1*C*). On the lateral view, there was a marked anterior bulging of the ventricular septum. The pulmonary artery and its branches appeared normal. The pulmonary veins entering the left auricle appeared somewhat dilated and the left auricle was moderately enlarged and displaced to the right by the huge left ventricle. The left ventricular chamber opacified well and appeared to account for two-thirds of the cardiac shadow. The contrast medium lingered in the left chambers for a prolonged period. A marked thinning of the muscular wall was noted at the cardiac apex with gradual increasing thickness towards the base (Fig. 1*D*). Pulsations of the left ventricle were not apparent.

The clinical findings in conjunction with the angiocardiogram and electrocardiogram established the diagnosis of anomalous left coronary artery arising from the pulmonary artery. The size of the left auricle indicated probable in-

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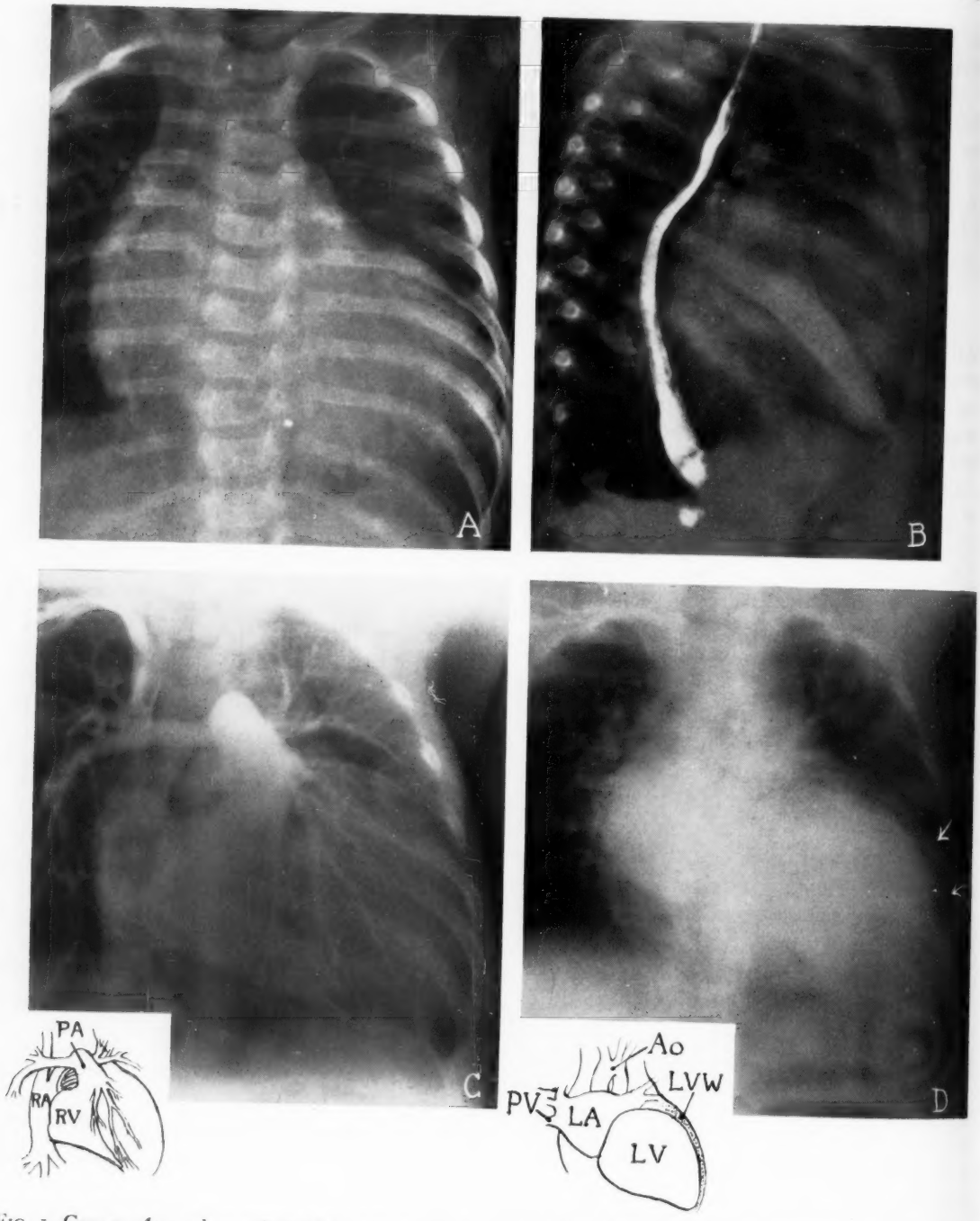

FIG. 1. Case 1. *Anomalous origin of the left coronary artery.* (*A* and *B*) Chest roentgenograms show marked cardiac enlargement and prominence of the left ventricular contour. On the lateral roentgenogram, the left atrium is displacing the esophagus posteriorly. Note the atelectasis of the lingula. (*C*) Angiocardiogram 1.8 seconds after injection reveals relatively small right chambers. Note the large unopacified area to the left of the ventricular septum. Despite the good opacification of the pulmonary artery, the aberrant left coronary artery arising from it does not visualize. (*D*) Angiocardiogram 5.6 seconds after injection shows a huge left ventricle bulging at the apex and displacing the left atrium to the right. The left ventricular wall appears thin at the apex, gradually becoming somewhat thicker towards the base.

(*Continued on next page*)

volvement of the mitral valve with subendocardial fibroelastosis.

Surgery. A cardiopneumopexy with phenol de-epicardialization and talc poudrage was performed. At surgery, the left ventricle appeared to be thin and white, showing very little pulsatile motion along its anterior aspect. The child tolerated the procedure well and was symptomatically improved when last seen six and one-half months postoperatively.

Case II. W.G., an eight and one-half month old colored male, was first seen at the age of three and one-half months because of abdominal "colic." The infant had been delivered by a cesarean section and the neonatal period had been unremarkable.

Clinical Examination. The infant appeared to be acutely ill and in severe respiratory distress. The use of the accessory muscles of respiration with intercostal and subcostal retractions was observed. The heart sounds were of extremely poor quality. The liver was enlarged. The urine showed 3 plus albuminuria.

Electrocardiogram. Multiple studies revealed sinus tachycardia and a pattern simulating acute anterior myocardial infarction. The ST segments were elevated in Leads I, V_3L, V_5, and V_6. Later, inversion of the T-waves in Leads I, AVL and V_6 appeared. Deep Q waves were subsequently noticed also in Lead I. The ST segments showed coving in V_6.

Roentgen Examination. A chest roentgenogram demonstrated cardiomegaly with left ventricular preponderance. The lung fields were clear. In follow-up roentgenograms obtained during the next few months, atelectasis of the left lower lobe appeared. Chest fluoroscopy confirmed the impression of the left ventricular preponderance.

Angiocardiogram. The visualization of the cardiac chambers was not optimal because of a rather slow rate of injection of the contrast medium. The right auricle and ventricle appeared normal in size and displaced anteriorly (Fig. 2, *A* and *C*). The vascularity appeared increased in the right lung and diminished on the left side due to the atelectasis of the left lower lobe and compensatory emphysema of the left upper lobe. The left auricle was rather small in size but displaced superiorly and to the right. Opacification of the left ventricle developed slowly but persisted for at least five seconds. This chamber was thin-walled at the apex with gradual increase in thickness towards the base (Fig. 2*B*). The muscular wall measured only 2 mm. in width at the apex and appeared compressed against the left thoracic cage. No evidence of systolic contraction at the apex of the left ventricle was demonstrated on serial roentgenograms.

Course. Subsequently, a Grade II systolic murmur and a striking gallop rhythm developed. The electrocardiographic findings of acute anterior myocardial infarction with elevated ST segments persisted for the five months during which the child was followed. At eight and one-half months of age, the infant died of ventricular fibrillation during an attempted surgical revascularization procedure.

Postmortem Findings. The heart weighed 220 gm. compared to the normal of 50 gm. at this age. The epicardium was transparent save for an approximately 2.5 cm. broad area over the left ventricle which showed a purplish discoloration. The atria were slightly enlarged. The right ventricular chamber was almost obliterated by a marked bulging of the intraventricular septum. The left ventricle was globoid with a 50 cc. capacity. Below the area of discoloration, the myocardium was extremely thin measuring only 2–3 mm. At the base, however, the left ventricular myocardium was approximately 9 mm. thick. The right coronary artery was normal in origin and distribution. The left coronary artery arose from the pulmonary artery immediately above the lateral cusp, but had a normal distribution. The hemorrhagic mottling of the thinned out myocardium of the left ventricular wall suggested a

Symbols in this and subsequent figures:

RA—right atrium
RV—right ventricle
LA—left atrium
LV—left ventricle
LVW—left ventricular wall
VS—ventricular septum
PA—pulmonary artery
PV—pulmonary vein
Ao—aorta
AoV—aortic valve
RCA—right coronary artery
LCA—left coronary artery
LLL—left lower lobe

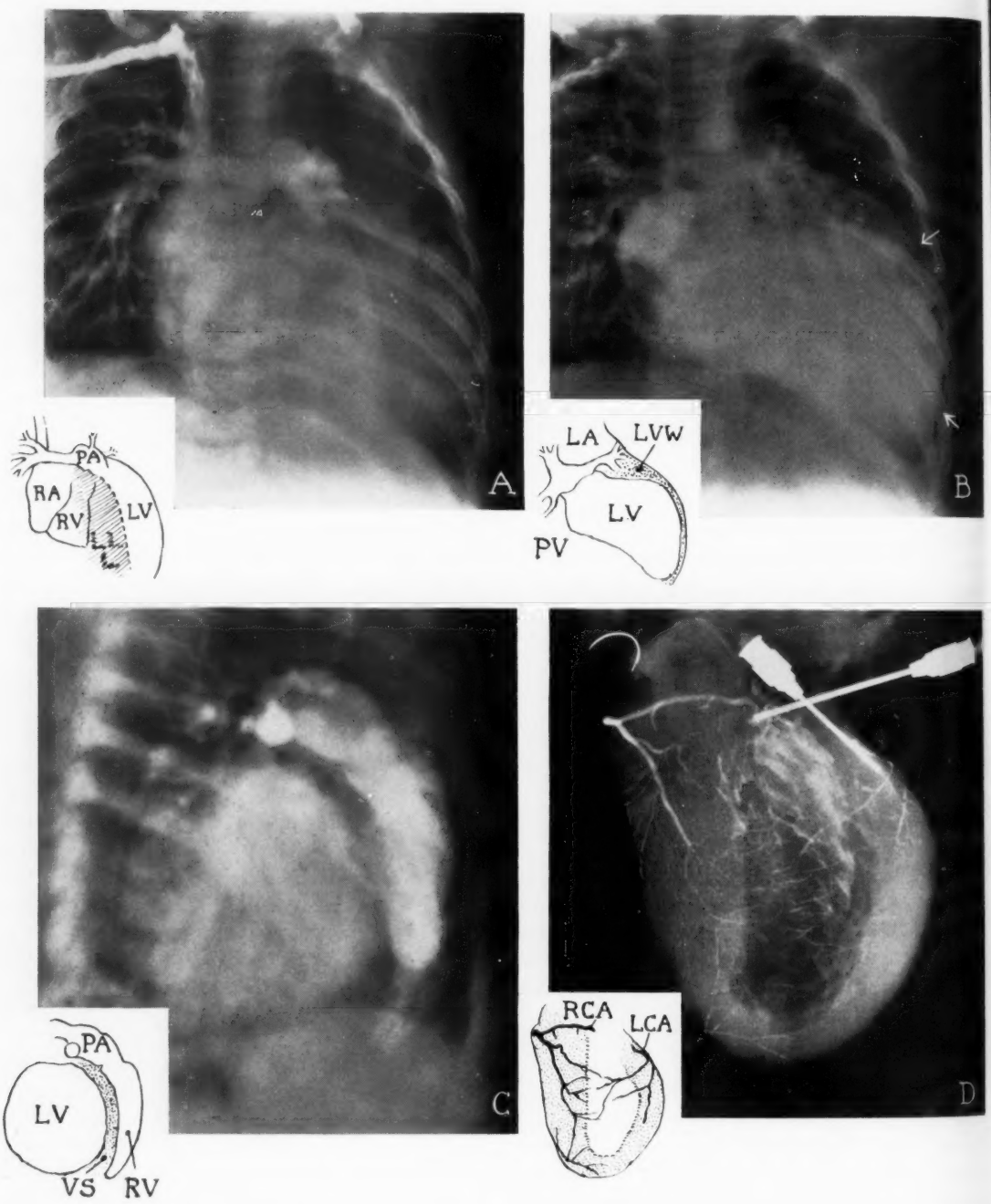

FIG. 2. Case 11. *Anomalous origin of left coronary artery.* (*A*) Angiocardiogram 3.7 seconds after injection shows normal-sized right chambers. The vascularity of the left lung is decreased due to atelectasis of the lower lobe (shaded area LLL) and compensatory emphysema of the upper lobe. (*B*) At 8.3 seconds, the small left atrium is seen displaced superiorly and to the right by the grossly dilated left ventricle. There is marked thinning of the left ventricular wall at the apex, and an increase in thickness at the base. The elongation and prominence of the apical region is striking. (*C*) Lateral view at 6.7 seconds shows both ventricles opacified. The ventricular septum is increased in thickness, and is bulging anteriorly, due to the marked left ventricular enlargement. (*D*) Heart specimen after injection of 1 cc. of thin barium mixture into the right coronary ostium. Reflux via collaterals into the smaller left coronary artery is demonstrated.

fresh infarct; however, the left anterior descending branch of the coronary artery was patent, although small. Microscopically, there was evidence of endocardial fibroelastosis, hyalinization and focal calcification in the myocardium. The aorta was slightly constricted at the site of the closed ductus arteriosus. The right coronary ostium was injected with 1 cc. of a thin barium mixture; specimen roentgenograms demonstrated reflux filling of the small anomalous left coronary artery via collaterals (Fig. 2*D*).

Case III. N.L., a six month old Chinese female, was thought to be healthy at birth, but failed to thrive in the neonatal period. At the age of three months, the infant developed a cold with rapid respirations. A chest roentgenogram at that time showed cardiac enlargement. Intermittent cough, vomiting, and dyspnea persisted after the upper respiratory infection subsided. The baby was never cyanotic.

Physical Examination. The infant was chronically ill with moderately severe respiratory distress, occasional grunting respirations and intercostal and subcostal retractions. A flat percussion note over the entire left chest and diminished to absent breath sounds were noted. There was a soft systolic murmur in the first left interspace.

Electrocardiogram. There was evidence of left axis deviation, left ventricular hypertrophy, signs of left ventricular ischemia and a delayed atrioventricular and interventricular conduction. Deep Q waves were noted in Leads I, V_5, and V_6. The T-waves were inverted in Lead I. The ST segments were elevated in Leads II, III, V_1, V_5, and V_6.

Roentgen Examination. There was marked cardiac enlargement completely encroaching on the left lower lung field. The pulmonary vascular markings appeared slightly increased. On fluoroscopy, expansile pulsations and enlargement of the left atrium were detected, with posterior displacement of the barium-filled esophagus. The left ventricle was markedly enlarged and pulsations along its left border were absent.

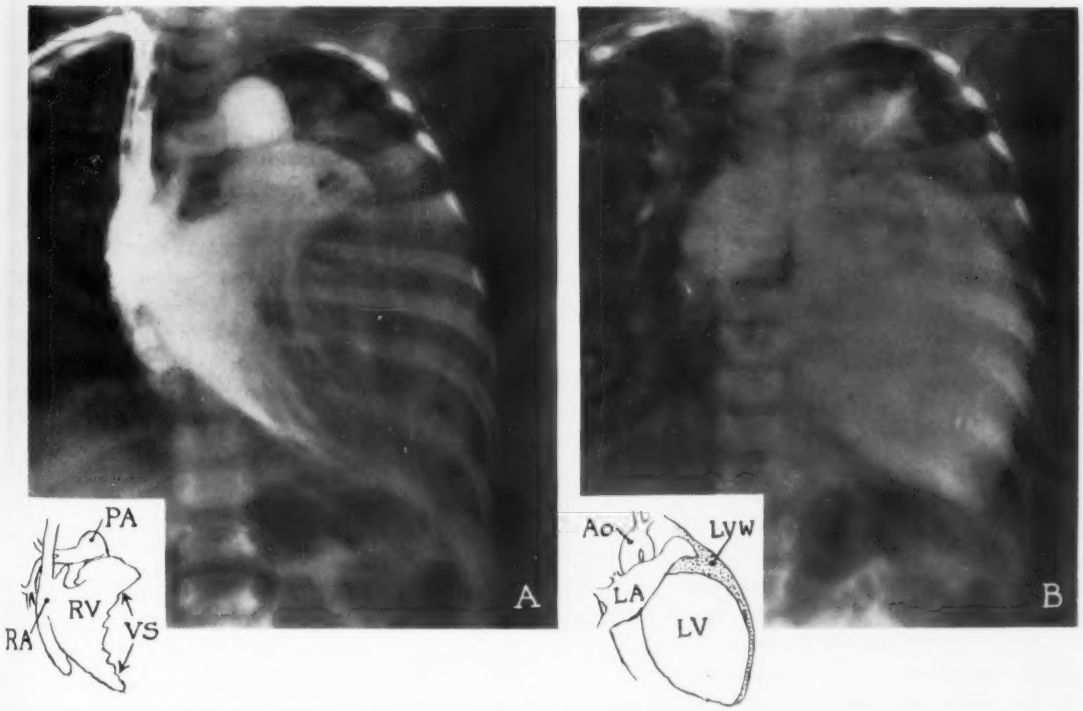

Fig. 3. Case III. *Anomalous origin of left coronary artery.* (*A*) Angiocardiogram 1 second after injection reveals right chambers and a pulmonary artery of normal size. Note the increased curvature of the ventricular septum. (*B*) At 5.4 seconds, the left atrial displacement to the right and superiorly and the enormous left ventricle are demonstrated. The left ventricular wall is very thin at the apex and thick at the base. The apical portion of the ventricular cavity is quite pointed.

Angiocardiogram. The right atrium was normal. The right ventricle was displaced to the right (Fig. 3*A*) and compressed anteriorly against the sternum. The left atrium first opacified at three seconds and was displaced to the right and superiorly. Immediately thereafter, the huge left ventricle opacified for at least four seconds indicating an abnormally slow circulation. Rapid serial roentgenograms demonstrated ineffective systolic contractions of this chamber. The left ventricular wall appeared abnormally thick at the cardiac base and very thin at the apex (Fig. 3*B*).

The angiocardiographic findings and the infarct pattern of the electrocardiogram established the diagnosis of anomalous left coronary artery. The patient was discharged on digitalis and expired one month later in another hospital.

Postmortem Findings. The heart weighed 137 gm. compared to the normal of 34 gm. for this age group. The pericardial sac was smooth and shiny and contained approximately 10 cc. of clear amber fluid. The right ventricular wall was thickened and pearly white, measuring 4 mm. The left ventricle was markedly enlarged and its wall measured 10 mm. at its base. There was, however, an area over the anterior surface of the left ventricle measuring 3 by 4.5 cm., where the myocardium appeared to be thin and pliable. The thickness of the wall in this area was only 1 mm. The left coronary artery arose from the pulmonary artery. The right coronary artery was normal in distribution and origin. The foramen ovale and ductus arteriosus were closed, and the tricuspid valve was bicuspid. Endocardial fibroelastosis was seen microscopically.

CASE IV. L.T., a ten month old white female, appeared well at birth, but at the age of six weeks began to have difficulty during feedings. At the age of five and one-half months, rapid labored respirations and circumoral cyanosis suddenly developed. A roentgen examination revealed atelectasis of the right upper and lower lobes and cardiac enlargement. During the next four months, increasing frequency of attacks of rapid respirations and respiratory grunts was noted. No generalized cyanosis was seen.

Physical Examination. There was no cyanosis or clubbing. Respirations were labored with expiratory grunts and subcostal retractions. An apical gallop rhythm was heard.

Electrocardiogram. The tracings showed evidence of right and left ventricular hypertrophy, sinus tachycardia and right axis deviation. The ST segments were elevated in Leads III, V_1 and V_3L. Later tracings showed inversion of T waves in V_5 and V_6.

Roentgen Examination. Marked enlargement of the heart and left ventricular preponderance were demonstrated. There was partial atelectasis of the right upper lobe. In addition, chest fluoroscopy showed left atrial enlargement and straightening of the pulmonary artery segment.

Angiocardiogram. The right chambers appeared normal in size, but the right ventricle was displaced anteriorly and to the right. The left chambers opacified in the third second and both were markedly enlarged. The left ventricle remained opacified for several seconds indicating a slow circulation time. This chamber failed to show systolic contractions on multiple serial films and its wall was thinned at the cardiac apex. The left auricular enlargement suggested a possible mitral valvular lesion. The left atrial enlargement and an unexplained cardiac murmur which developed during hospital stay made the diagnosis uncertain. The patient expired during an attempted cardiac catheterization.

Postmortem Findings. The left ventricle was markedly dilated. The epicardium of the apex showed areas of ecchymoses and the underlying myocardium showed mottling and fresh hemorrhages. Diffuse endocardial fibrosis of the left atrium and left ventricle was observed. The anterior papillary muscles were atrophic. The anterior leaflet of the mitral valve was thickened. The right coronary artery was normal. The left coronary artery originated from the pulmonary artery; however, its distribution was normal. The ductus arteriosus and the foramen ovale were closed. Fresh hemorrhages were seen in the lung parenchyma.

CLINICAL MANIFESTATIONS

From the literature on anomalous origin of the coronary arteries (summarized in Table 1), it is apparent that the most common form of this anomaly involves the left coronary artery and presents clinically in infancy. The relatively few instances in adults[1,14,21,31,36,47,53,54,69] were seen either as incidental postmortem findings or in patients who died suddenly without preced-

TABLE I

SUMMARY OF FINDINGS IN 66 CASES OF ANOMALOUS ORIGIN OF THE CORONARY ARTERIES (INCLUDING AUTHORS' 4 CASES)

		Left Anomalous Coronary Artery in Infants	Left Anomalous Coronary Artery in Adults	Right Anomalous Coronary Artery in Adults	Both Coronary Arteries Arising Anomalously
Clinical Findings	Total number with information available	42	8	1	6
	Mean age at onset of symptoms	2 mo.	—	—	birth
	Dyspnea				
	persistent	0	0	0	6
	exertional	34	0	1	—
	terminal	10	0	—	—
	Attacks of pain	10	2	0	—
	Feeding difficulties	21	0	0	6
	Respiratory infections	26	0	0	0
	Transient minimal cyanosis	17	0	0	—
	Persistent cyanosis	0	0	0	6
	Pallor	18	0	0	2
	Cardiac murmurs	5	0	1	2
	Sudden death	13	7	0	—
Electrocardiographic Findings	Total number with information available	18	1	—	1
	Myocardial infarction pattern	18	1	—	0
Roentgenologic Findings	Total number with information available	24	—	—	2
	Cardiac enlargement	24	—	—	1
	Left ventricular enlargement specified	17	—	—	0
	Apical aneurysmal dilatation specified	5	—	—	0
	Decreased pulsations of the left ventricle specified	4	—	—	—
	Normal	0	—	—	1
	Atelectasis	8	—	—	0
Pathologic Findings	Total number with information available	44	9	3	6
	Age range at death	2–13 mo.	17–64 yr.	30–90 yr.	9 hr.–13 da.
	Mean age at death	5 mo.	—	—	6 da.
	Left ventricular enlargement	43	7	1	2
	Aneurysmal dilatation at apex specified	24	3	0	0
	Myocardial rupture	2	0	0	0
	Deviation of interventricular septum to the right specified	11	0	0	0
	Flattening of the anterior papillary muscles	15	2	0	0
	Subendocardial fibroelastosis or fibrosis	32	3	0	0
	Myocardial fibrosis	40	7	1	0
	Myocardial calcifications	25	3	0	0
	Fresh myocardial infarct	10	0	0	3
	Intima proliferation of the small arteries specified	6	4	0	—
	Embryonal sinusoids specified	16	3	0	0
	No myocardial changes	0	1	2	1
	Other cardiac anomalies	5	0	0	2
Operative Results	Total number operated on	3	—	—	—
	Improved	2	—	—	—

ing serious symptoms. In the few instances of anomalous origin of both coronary arteries,[3,22,42,62,63,68] death occurred within the first two weeks of life. No significant difference in incidence was noted in males and females; at least 11 instances of the anomaly have occurred in the colored race and at least 1 has occurred in an Oriental (Case III, N.L.).

The clinical history of most of the infants is remarkably uniform. They appear normal at birth and asymptomatic for the first few weeks of life. Feeding difficulties tend to ensue in the second month. Attacks of dyspnea, cough, cyanosis or pallor, restlessness, "colic," perspiration, drawing up of the legs or extension of the neck occur during or after feeding. These are probably manifestations of angina pectoris. Transient or circumoral cyanosis is common but persistent generalized cyanosis has not been observed. Soft blowing systolic murmurs are sometimes heard but, more frequently, murmurs are absent. Recurrent respiratory infections are common, and congestive failure often ensues. The infants frequently die suddenly. The majority die between the ages of two and one-half to thirteen months.

In the asymptomatic neonatal phase, the high pulmonary artery pressure and patency of the ductus arteriosus probably help to maintain a reasonably adequate coronary blood flow.[17,60,66] Later, however, the fall in the pulmonary artery pressure and increasing work load of the left ventricle result in anoxia and myocardial damage. The secondary stasis further decreases the pulmonary and left coronary flow, and a vicious cycle is established.

The typical electrocardiographic pattern was first described by Bland, White, and Garland.[7] An acute anterolateral infarction pattern is usually seen which in this age group is almost pathognomonic. ST segment elevation and inversion of the T waves are commonly observed; there may or may not be left axis deviation. This pattern is simulated in infants only in rare cases of aortic stenosis or aortic hypoplasia with disturbed coronary blood flow. The pattern in subendocardial fibroelastosis[24,40,41,67] is usually quite different.

PATHOLOGIC FINDINGS IN ABERRANT LEFT CORONARY ARTERY

The aberrant left coronary artery usually arises from the pulmonary artery above the lateral pulmonic cusp, and no ostium is visible on the left side of the aorta. The course and distribution of the artery beyond its origin are usually normal. Two embryologic theories[23,69] have been advanced to explain the anomaly. The aorticopulmonary septum which divides the common arterial trunk may be malrotated so that the ostium of one coronary artery is included in the pulmonary side rather than the aortic side of the septum. According to the second theory, the anlage of the bud of the anomalous coronary artery develops from its beginning at an unusual location. This anomaly usually occurs as an isolated entity; only 5 of the recorded cases showed other cardiac abnormalities.

The heart is usually three to four times its normal weight postmortem, chiefly due to tremendous left ventricular enlargement. The right chambers have frequently shown mild dilatation and hypertrophy secondary to left ventricular failure. The right ventricular cavity has sometimes been markedly narrowed by the bulging ventricular septum.

There has been confusion in the literature as to whether the left ventricular wall is hypertrophied or thinned. In all cases, the ventricular septum, base, and posterior wall of the left ventricle showed marked hypertrophy. In most instances, localized thinning of the myocardium with flattening of the trabeculae was described at the apex and anterior ventricular wall, the areas dependent on the left coronary artery for blood supply. Aneurysmal bulging of the cardiac apex was mentioned in 24 out of 44 autopsies and in 2 cases,[33,45] rupture occurred. These areas microscopically have shown myocardial necrosis, hyalinization, flecks of calcification and extensive fibrous

replacement, chiefly in the subendocardial layers. The left anterior papillary muscle has been atrophic. The endocardium of the left ventricle and sometimes of the left atrium has been thickened and dull gray in appearance due to fibroelastic thickening. Endothelial-lined myocardial sinuses, perhaps due to remnants of embryonic sinusoids, have been encountered in the subendocardial myocardium in about one-half of the cases. The smaller arteries have shown marked intimal proliferation, thinning of the media, and adventitial fibrosis. The lesions of the left ventricular wall just described have been attributed to ischemia and increased intraventricular pressure.

In the adult cases of aberrant left coronary artery, the left ventricular lesions have been less marked than in infancy, or even absent. The left coronary has usually been dilated and thin-walled, resembling a vein. The right coronary has been markedly dilated, tortuous, and cirsoid, with an extensive collateral circulation. Coronary atherosclerosis when present has involved only the right coronary.

ROENTGENOLOGIC FINDINGS

Including the authors' 4 cases, chest roentgenograms were obtained in 24 of the 44 cases in infancy. Chest fluoroscopy was performed in only 6 instances and thoracic aortography in only 1.[48]

Chest roentgenograms show marked cardiac enlargement with left ventricular preponderance. The pulmonary vascularity is usually either normal or slightly increased; marked pulmonary congestion is not frequently seen. Atelectasis of the left lower lobe is common, probably due to compression of the left lower bronchus by the enlarged left ventricle; however, atelectasis of the right lung is not unusual.

Fluoroscopically, the pulsations along the prominent left ventricular border are strikingly decreased or absent. The right ventricular pulsations are normal. Left atrial enlargement with posterior displacement of the barium-filled esophagus is occasionally seen, probably due to endocardial fibroelastosis involving the mitral valve.

Thoracic aortography obtained by rapid injection through a catheter in the ascending aorta demonstrated filling of the coronary artery only on the right side in at least 1 unpublished case. This was presumptive evidence that the left coronary artery was either absent or aberrant. Nonvisualization of the left coronary artery, however, has occurred fortuitously in the presence of a normal vessel. Paul and Robbins[48] failed to demonstrate the coronary arteries by retrograde aortography in 3 infants three and one-half to eight and one-half months of age. The size of the arteries into which the retrograde catheter must be inserted was a definite limiting factor. Spasm of the coronary arteries or improper positioning of the catheter may also render this procedure unsuccessful. Angiocardiography would appear to be a more conclusive study.

ANGIOCARDIOGRAPHIC FINDINGS

With an intravenous injection, visualization of all the cardiac chambers is usually good despite the marked cardiac enlargement and slow circulation time, because of the absence of intracardiac shunts. The right chambers are usually normal in size, but the right ventricle is often displaced to the right and compressed anteriorly against the sternum by the grossly enlarged left ventricle. The posterior and left margins of the right ventricle are rendered concave by the bulging ventricular septum. The pulmonary artery and its branches usually appear normal. Opacification of the left coronary artery from the pulmonary artery is not seen.

The left atrium may be normal or slightly enlarged; more marked degrees of enlargement should suggest mitral stenosis. It is often displaced to the right and superiorly by the large left ventricle. It may be rotated so that its left side is higher than the right (Fig. 2*B* and 3*B*).

The left ventricular chamber usually remains opacified for a prolonged period be-

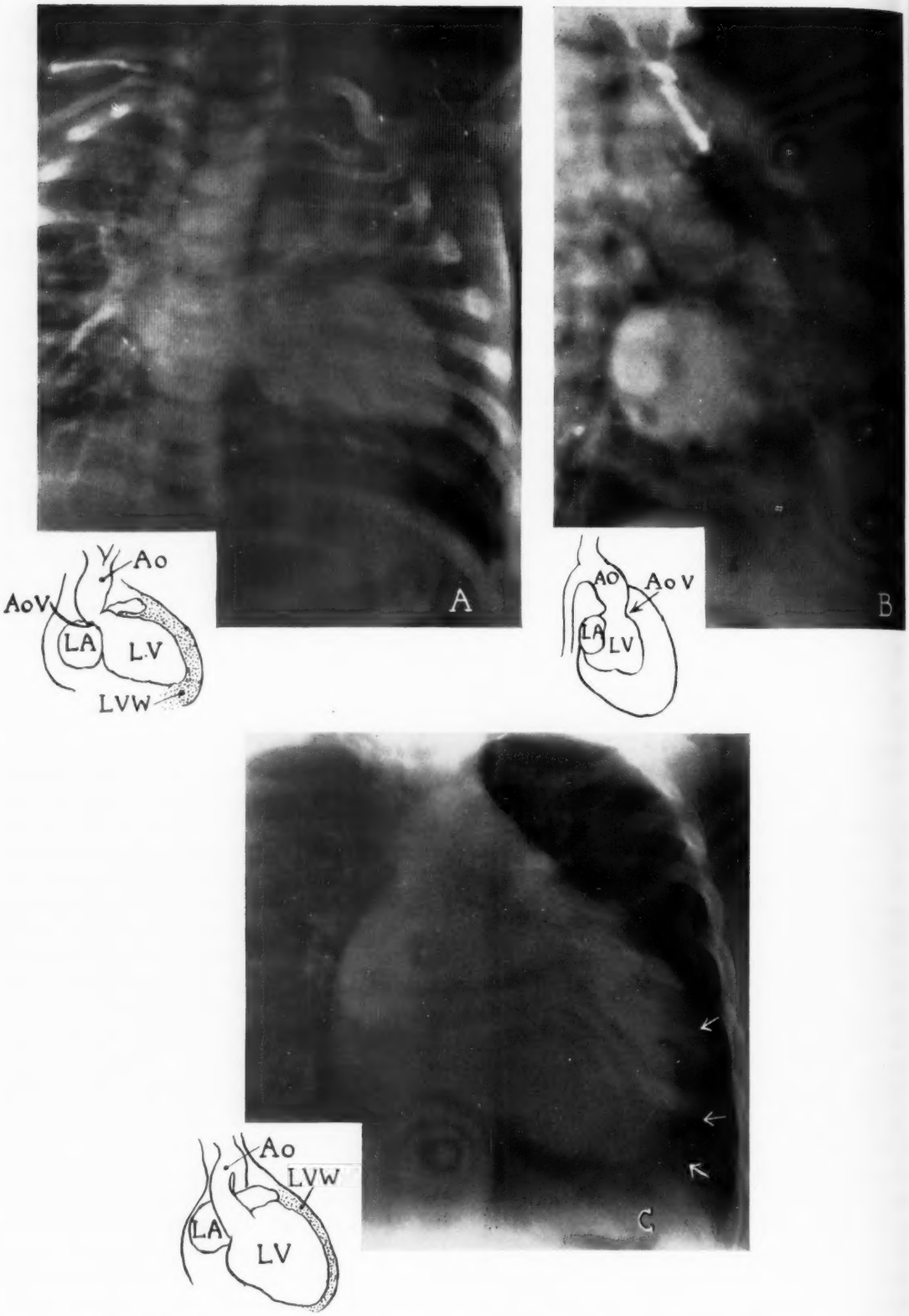

FIG. 4. *Anomalies simulating aberrant left coronary artery.* (*A* and *B*) Congenital aortic stenosis, autopsy proved. The wall at the apex of the left ventricle is grossly hypertrophied rather than thinned. A slight constriction is seen at the origin of the aorta, with dilatation of the ascending portion. (*C*) Subendocardial fibroelastosis, autopsy proved. The wall of the large left ventricle is moderately and uniformly thickened from apex to base. There is no localized bulging at the apex.

cause of its huge size and because of the slow circulation time. When rapid serial roentgenograms are obtained at the rate of 4 to 6 frames per second, the absence of effective systolic contractions is apparent. The hypertrophied left ventricular wall is seen at the base of the heart in the anteroposterior views, and in the ventricular septum in the lateral views. In contrast, the apical region shows marked thinning of the wall. Actual measurements from the roentgenograms do not exceed 2 to 3 mm. As a result of this thinning, the opacified left ventricular cavity develops a rather pointed and localized bulge at the apex (Fig. 2*B*). The aorta appears normal.

DIFFERENTIAL DIAGNOSIS

The distinction between this entity and other conditions producing marked left ventricular enlargement in infancy can usually be made by angiocardiography (Fig. 4). Subendocardial fibroelastosis, congenital aortic or subaortic stenosis, Fiedler's idiopathic myocarditis, Von Gierke's glycogen storage disease and rhabdomyoma produce left ventricular enlargement, poor systolic contractions, and prolongation of the circulation time. In all of these conditions, however, the left ventricular wall is thickened maximally at the apex in contrast to the apical thinning of aberrant left coronary artery. The left ventricular cavity does not develop an elongated and pointed apex. In a few instances of severe aortic or subaortic stenosis, the actual site of narrowing may be demonstrated on the angiocardiograms (Fig. 4, *A* and *B*). In primary diseases of the myocardium such as idiopathic myocarditis and glycogen storage disease, both ventricles are equally dilated. Disproportionate enlargement of the left ventricle, marked bulging of the ventricular septum and displacement of the right chambers do not occur. In rhabdomyomas of the left ventricle, the grossly enlarged left ventricular chamber either visualizes poorly or a gross filling defect is apparent within its cavity. Marked bulging of the ventricular septum may occur.

In the future, if angiocardiograms are performed on infants with aberrant left coronary arteries within the first weeks of life, it is conceivable that the myocardial apical thinning may not be as apparent as in the present studies.

SUMMARY

Four cases of anomalous origin of the left coronary artery from the pulmonary artery are reported. The diagnosis was made angiocardiographically by a characteristic thinning of the myocardium near the apex and by the absence of pulsations of the huge left ventricle. The diagnostic and pathologic features in 62 collected cases of anomalous origin of the coronary arteries are briefly reviewed.

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ADDENDUM

Since completion of this paper, another instance of Bland-White-Garland syndrome was encountered in a three month old white female, T. W. The characteristic angiocardiographic findings were again demonstrated and the diagnosis confirmed during a cardiopneumopexy.

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REACTION OF THE HEART TO SELECTIVE ANGIOCARDIOGRAPHY*

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ANGIOCARDIOGRAPHY is now an accepted, well recognized and almost fully standardized procedure. Selective angiocardiography, however, is presumably in the process of proving its worth. It is not the purpose of this paper to repeat what has been so well demonstrated by others concerning its values.[5,14,16,19,24] This study was undertaken because of the misgivings which arose concerning the possible complications of the procedure and particularly because of a desire to evaluate the physiologic aberrations that could be produced by the forcible injection of contrast materials directly into the heart. Cournand and co-workers'[6] American Heart Association Committee Report on Cardiac Catheterization and Angiocardiography refers to selective procedures only in passing. Dotter and Jackson[7] specifically exclude 2 fatalities following injection per catheter from their collected series of 26 angiocardiographic deaths.

METHOD OF STUDY

An attempt was made to study the various traumatic factors contributing to selective angiocardiography, *e.g.*, reaction of the heart to the catheter, to the contrast medium, to the force, rate and volume of the injection and to the radiation exposure required for the procedure. The possible psychogenic complications were not included because they did not seem amenable to this type of study, although a psychogenic effect upon the heart is not inconceivable.

The material at hand consists of 334 cardiac catheterizations, 159 selective angiocardiograms, 23 conventional angiocardiograms and 10 left heart punctures in human subjects. Sixty-four dogs were subjected to studies designed to clarify the safe limits of the traumatizing factors involved.

Continuous electrocardiographic tracings were recorded on all subjects throughout the procedure. An electrical signal marked the instant of injection and the instant of exposure during the angiocardiographic series. Pre- and post-injection intracardiac pressure tracings were recorded in all of the experimental animals and in 9 of the human patients undergoing this examination. Respiratory activity was recorded in each case. Finger plethysmography proved disappointing and was used in only 9 patients before being abandoned. Electroencephalographic tracings had been planned but Kirstein and co-workers'[15] report made these unnecessary.

The hearts of 29 of our patients were inspected at the time of surgery and none showed lesions attributable to any phase of selective angiocardiography. Eighteen of the patients who subsequently died came to autopsy. None of the human deaths were attributable to selective angiocardiography. Twenty-six of the experimental animals were studied post mortem. In many of these the exaggerated procedures employed resulted in the death of the animal or would have caused severe morbidity if the animals had not been sacrificed.

RESULTS

Reaction to the Catheter. Some authors have expressed fear of knotted catheters. It is difficult to knot the catheters intentionally. When this can be done experimentally, intermittent forceful hydrostatic pressure usually unties the simple loop knot encountered. Others report surgical solutions to this problem.[16]

In 2 persons irritable sino-atrial nodes

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were found during catheterization prior to angiocardiography. One of these was carried on to successful angiocardiography by avoiding the upper right portion of the right atrium. In the other, several periods of diastolic arrest caused the procedure to be abbreviated (Case 1, Fig. 1).

CASE 1. O11-95-26. A white male of four months had been known to have a Grade IV harsh systolic murmur since four weeks of age. This was best heard in the fourth intercostal space. There was no cyanosis. Pulse rate 100; respiratory rate 40; height 48 cm.; weight 3.24 kg.; mean blood pressure 60 mm. Hg. The electrocardiogram showed right axis deviation and combined hypertrophy.

There had been poor weight gain since birth. He was hospitalized at the age of seven weeks and at the age of twelve weeks for cardiac failure. He had been digitalized and presently was receiving digitalis. Congenital anomalies were noted in the eyes, nose and ears. The anus was stenotic, and a secondary megacolon was present. Clinical diagnosis: interventricular septal defect.

Under basal anesthesia a No. 5 Cournand catheter was passed through the right saphenous, femoral, inferior caval veins and right atrium into the infundibulum of the right ventricle. The heart stopped beating for three seconds, and the catheter was withdrawn into the atrium. When it touched the superior lateral aspect of the atrium (Fig. 1) the heart stopped again for two seconds. The beat when resumed was slow and full. This appeared to be a "vagal escape" mechanism. This series of events occurred in this patient on two other occasions. A limited number of samples were obtained. These showed a left to right atrial shunt. The examination was discontinued. No angiocardiography was performed.

Diagnosis: (1) Interatrial septal defect; (2) irritable sino-atrial lymph node and infundibulum; (3) not sufficient information about ventricular function.

In 2 children bradycardia was noted when the tricuspid valve was held open by a catheter loop. Both of these children had pulmonic stenosis of moderate severity. In one of them and in 2 others, bradycardia and diminished cardiac output occurred when the catheter lay for a short time within the stenotic pulmonary valve. Of these

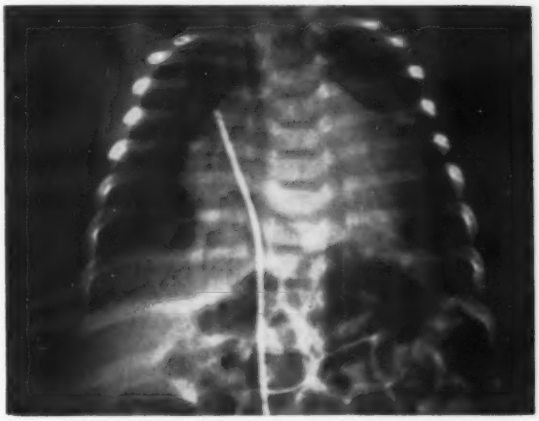

FIG. 1. Case 1. Catheter tip is in sino-atrial lymph node region. Cardiac arrest, "vagal escape," and bradycardia followed. A normal beat was resumed, but angiocardiography was not performed despite the need for further information about the ventricular system and great vessels.

3, 2 died. In one angiocardiography was not done (Case II, Fig. 2).

CASE II. O12-46-55. A fifteen month old white female infant had a Grade III harsh systolic cardiac murmur since birth. This was audible over the entire precordium and was associated with a pulmonic thrill. At one year of age her parents noted a progressive cyanosis of the hands and feet. Mean blood pressure determined was 64 mm. Hg by flush technique. A moderate polycythemia was present. The pulmonary vessels were small as was the waist of the heart as seen in the roentgenogram. There was electrocardiographic evidence of extreme right ventricular hypertrophy. Preoperative diagnosis: tetralogy of Fallot.

At right heart catheterization systolic pressure in the main pulmonary artery was found to be 9 mm. Hg. A severe bradycardia developed. The rate returned to normal upon withdrawal of the catheter into the right ventricle. A period of cardiac asystole lasting approximately twenty seconds was noted upon occlusion of the narrowed pulmonary arterial valvular orifice (Fig. 2). Upon immediate withdrawal of the catheter from the orifice into the cavity of the right ventricle a sinus tachycardia developed. After several minutes the right ventricular pressure returned to its former status, 169 /0 mm. Hg. Oxygen saturations were found to be extremely low, ranging from 31 to 42 per cent, presumably due to a low cardiac output. While awaiting surgery for pulmonic stenosis,

FIG. 2. Case II. The jet stream entering the main pulmonary artery reflects the size of the pulmonic valve orifice. When a catheter of the size noted above passes through the pulmonic valve, it can easily act as an obturator.

cardiac arrest suddenly occurred, and despite thoracotomy and emergency valvulotomy the patient died.

Almost invariably premature ventricular contractions were produced upon passing the catheter through the right ventricular outflow tract. In the hands of skillful operators this proved no impediment to completion of the procedure. When the catheter was being manipulated less skillfully, runs of premature ventricular contractions impelled temporary withdrawal of the catheter. In no case was a ventricular fibrillation produced. In 4 patients varying degrees of heart block were momentarily noted. Reversion to normal rate and rhythm soon followed.

In animal experiments the catheter was passed via aorta into the left ventricle and left atrium. In 2 instances it became lodged in the left coronary artery. Fibrillation soon followed. It was extremely difficult to remove the catheter, presumably because of arterial spasm about it.

Perhaps the second most severe reaction to the catheter occurred in the animal experiments in instances where the catheter was left in place for relatively long periods of time.[19] Here subendocardial hemorrhages and thrombi were found in 85 per cent of dogs in which the catheter had remained in place for one hour or longer (Table I). Prolonged catheterization is, therefore, contraindicated and unnecessary delays between the catheterization and the angiography are to be avoided.

It seemed reasonable to suspect that intracardiac injection of an opaque medium under high pressure might produce some sort of identifiable disorder. A series of 68 experiments were performed in which the pressure within the various chambers of the heart was studied before, during, and after "high pressure" injection (Table II). Hypaque, miokon and normal saline in doses of 1–1.5 cc./kg. of dog were injected at 600 pounds per square inch pressure through No. 7 Cournand catheters. Recording was done by an Offner galvanometer system through P23D Statham Strain gauges via monitoring catheters in the various chambers. The only aberrations noted were sporadic, ventricular, premature contractions with concomitant momentary alterations in the ventricle under observation (Fig. 3). These changes were frequently unilateral. Studies by Nordenström[22] gave similar results.

Water, saline or iodinated contrast materials, when injected into the heart or great vessels, gave rise to the same sort of immediate intracardiac changes and, in general, these substances were not distinguishable from one another by the nature of this response. The temperature of the injected solutions had surprisingly little effect within the limits studied. One might expect a change in pulse rate on the order of 10 for each degree of variation from normal body temperature.[2] We noted no appreciable difference in pulse rate produced by injections at room temperature or at body temperature.

A slight increase in pulse rate upon injection into the right atrium of the human

TABLE I

RESULTS OF PROLONGED CATHETERIZATION. DOGS IN WHICH PATHOLOGIC FINDINGS WERE PRESENT AT AUTOPSY (CATHETERS IN HEART FOR A MINIMUM OF ONE HOUR)

Dog No.	Sites Injected	Sites Recorded	Sites with Pathology	Types of Pathology
3	right ventricle, 5 times	right ventricle and aorta	2 right atrium, 2 right ventricle, mitral valve	thrombus vegetations
4	right ventricle and left ventricle	right ventricle, aorta, carotid artery	subendocardium	hemorrhage
5	left ventricle	right ventricle, left ventricle	right atrium	thrombus
7	right ventricle*	right ventricle, left ventricle	2 right atrium, left ventricle	hemorrhage
8	pulmonary artery	right ventricle, left atrium	2 right atrium, aortic valve	thrombus, hemorrhage
9	pulmonary artery	left ventricle, carotid artery	aortic valve	hemorrhage
12	right atrium, left ventricle	right atrium, femoral artery	right atrium	thrombus
13	left ventricle	right ventricle, left ventricle	right ventricle, aortic valves	hemorrhage

* Five per cent glucose in distilled water injected.

subjects (Bainbridge reflex) was infrequently noted. Registration of respiratory activity aided in interpretation of the slow Traube-Herring waves which could easily be mistaken for pressure changes due to injection.

The electrocardiographic response was significantly affected by the quantity of material injected. The quality of the examination was also greatly affected by the quantity, as well as by the time necessary for the injection. Heart rate, chamber volume cardiac output, length and caliber of catheter, injection pressure, duration of injection, and density of the opaque material are all factors which determine the degree of opacification of the heart's content and thereby the success of the examination. It was desirable to inject a dose which would fill the chamber in question and which would still leave a discernible bolus of opaque material to follow through the sys-

TABLE II

ELECTRICAL AND PRESSURE CHANGES RELATED TO SITE OF INJECTION OF OPAQUE MEDIA IN 68 NORMAL DOGS

Site	No. Injections	No. with Abnormal Electrocardiogram	No. with Early Pressure Drop
superior vena cava	5	3	3
inferior vena cava	5	0	0
right atrium	6	4	3
right ventricle	14	13	10
pulmonary artery	5	2	2
left atrium	1	1	1
left ventricle	6	5	4
aorta	6	0	0

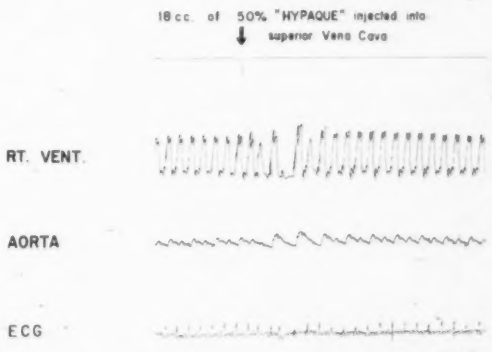

FIG. 3. Effect of injection upon electrocardiogram and upon aortic and right ventricular pressures. Ineffectual second, fourth, and sixth right ventricular contractions are noted with transient elevation and depression of right ventricular and aortic pressure.

FIG. 4. Case III. (*A* and *B*) Discrete opaque bolus can be followed through heart clearly defining the chambers within which it is seen.

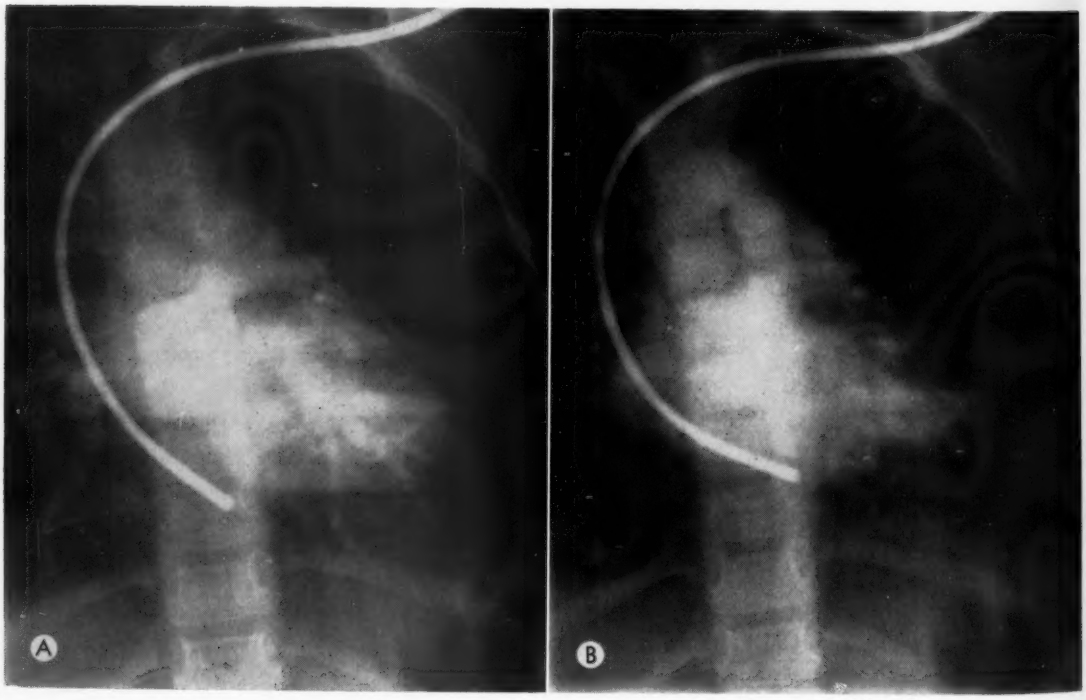

FIG. 5. Case III. (*A* and *B*) Note that the pulmonary artery is empty while the left atrium is filled. With contraction of the left ventricle, both the aorta and pulmonary arteries filled. The separation of the column thus achieved is diagnostic and indicates a recirculation, left to right, presumably through the interventricular septal defect.

tem (Case III, Fig 4, *A* and *B* and 5, *A* and *B*). In general, 1 cc./kg. body weight will do this.[14,19] Over 2 cc./kg. body weight yielded many more electrocardiographic abnormalities, more changes in pressure and, according to Dotter and Steinberg, more deaths than did the lower quantity. Lind, Spencer and Wegelius[18] believe that the injection should not last over two heart cycles. Kjellberg and Olsson[17] have devised a graph which indicates the quantity of opaque material passing through a catheter of a given size in a given time under certain injection pressures. For these studies a monitor was devised to indicate the duration of each injection on the electrocardiographic paper.

The pressure of injection could be controlled and, of course, this affected the speed at which a given quantity could be injected into the heart (Fig. 6, 7, *A* and *B*, 8, *A* and *B* and 9, *A* and *B*). The Gidlund automatic injection apparatus delivered 60 pounds per square inch when set at 1 atmosphere pressure.[9] This is approximately the pressure delivered by normal hand injection using normal saline in a 20 cc. Luer Lok syringe. Injection pressures 10 times greater than this were well tolerated by dogs but were associated with some long runs of extrasystoles in human patients. Seven times the normal hand pressure seemed acceptable. After the injection pressure on the Gidlund syringe was set to deliver a predetermined amount of the contrast substance within the predetermined time allotted, corrections were made for the size and length of the catheter and the pulse rate of the patient.

Reaction to the Contrast Media. Since the

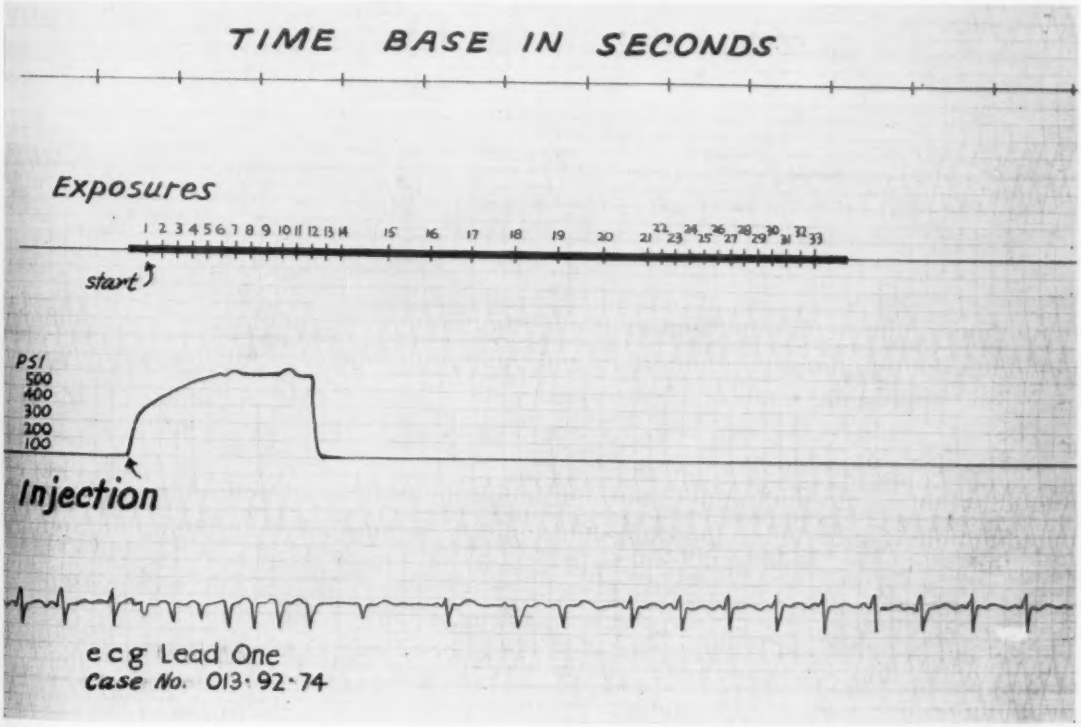

FIG. 6. Case IV. Typical monitor tracings in selective angiocardiography. Each "pip" on the time base line indicates passage of one second. Injection and exposures were started by a hand switch. The slope of injection pressure to the peak of 500 pounds per square inch is due to a defective valve and to some elasticity in the air column of injector. Eighteen cubic centimeters of 50 per cent miokon were injected through the No. 7 catheter in two seconds. During this period 11 exposures were made with others following as noted above. The electrocardiographic tracing (lead one) shows immediate inversion of the QRS complex with inversion and then flattening of T waves present for four seconds. Rhythm and wave form then remained normal.

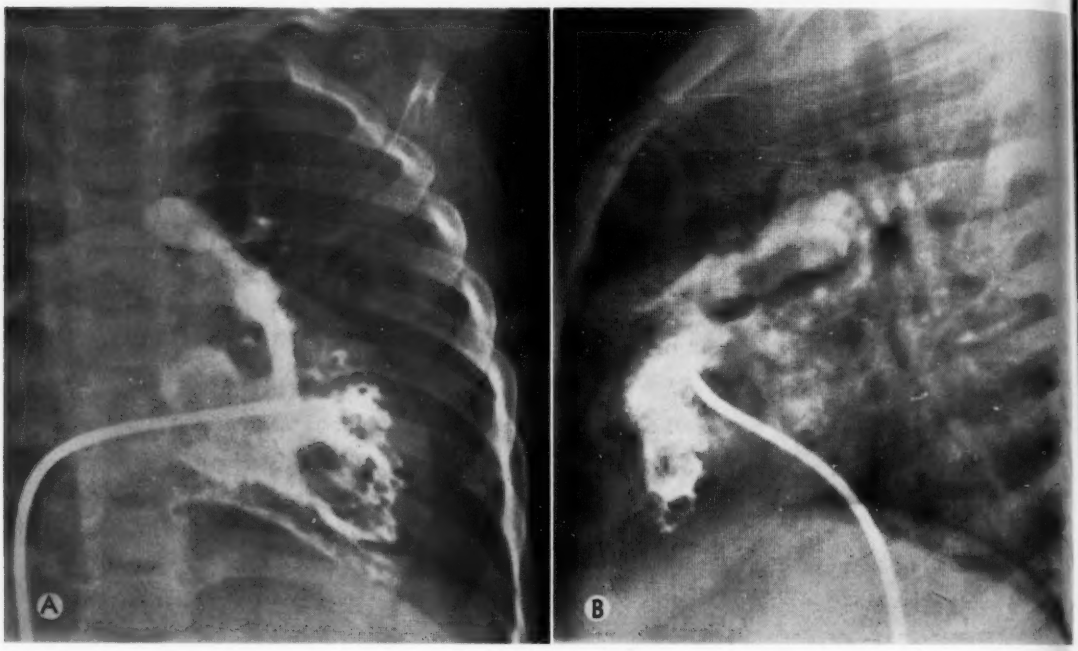

FIG. 7. Case IV. Eighteen kilogram, two year old male child. Cyanotic at three months, now peri-oral and peri-orbital cyanosis. Eighteen cubic centimeters of miokon 50 per cent were injected through a No. 7 Gidlund catheter into the right ventricle. (*A* and *B*) Exposure No. 5 demonstrates large right ventricle with right to left shunt. The pulmonary artery is hypoplastic. Its valves are stiff. A diverticulum is present superiorly.

report of the Committee on Cardiac Catheterization and Angiocardiography of the American Heart Association in 1953, several new contrast materials have become available. In our hands 50 per cent miokon and hypaque have exhibited less of a systemic effect on blood pressure than did diodrast, neo-iopax, or urokon. This blood pressure change, an immediate rise of 2–5 mm. Hg systolic and 6–9 mm. Hg diastolic pressure with a corresponding drop for thirty to sixty minutes, was thought to be due to cerebral and peripheral effects of the media and not to a reaction of the heart.

Some of the children (4.5 per cent) had elevations of temperature from 99–100°F., which in some cases lasted three days. This occurred as frequently in those who had catheterization only and, therefore, is probably not associated with a reaction to the media (Table III).

Central nervous system symptoms listed as complications of the procedure[4,8,15] have not been encountered in our series. There have been no deaths. Amounts no greater than 1.5 cc./kg. were injected. A minimum number of aortic injections had been done and these with low concentrations of the medium.

All of the materials injected have very low oxygen tensions compared with the usual content of the coronary artery. Prolonged suffusion angiocardiographically has caused electrocardiographic changes of myocardial ischemia.[8] Such events were observed in these studies when deliberate attempts were made to outline the safe margins of coronary angiocardiography.

Reaction to Coronary Angiography. Miokon 50 per cent was injected into the ascending aorta 2–3 cm. above the sinus of Valsalva in 27 dogs (Table IV). In general, the same dosage schedule was used as for intracardiac injection, although smaller quantities could have been used. The injections were made at 600 pounds per square inch pressure through a No. 9

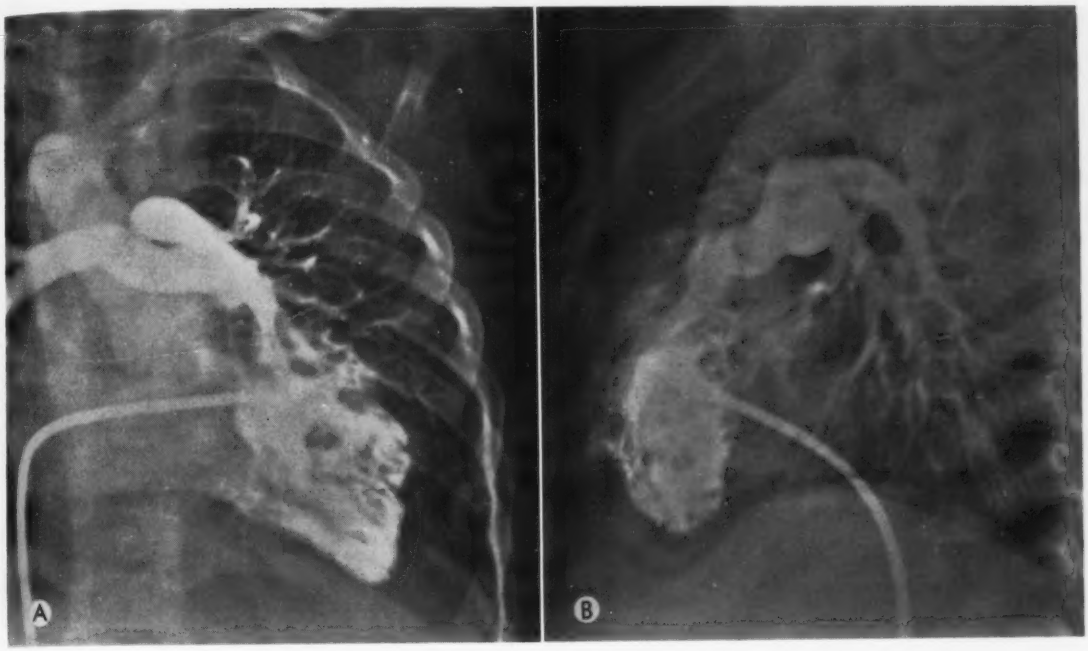

Fig. 8. Case IV. (*A* and *B*) Exposure No. 12 demonstrates that the aorta fills from the right ventricle and its orifice lies near the interventricular defect.

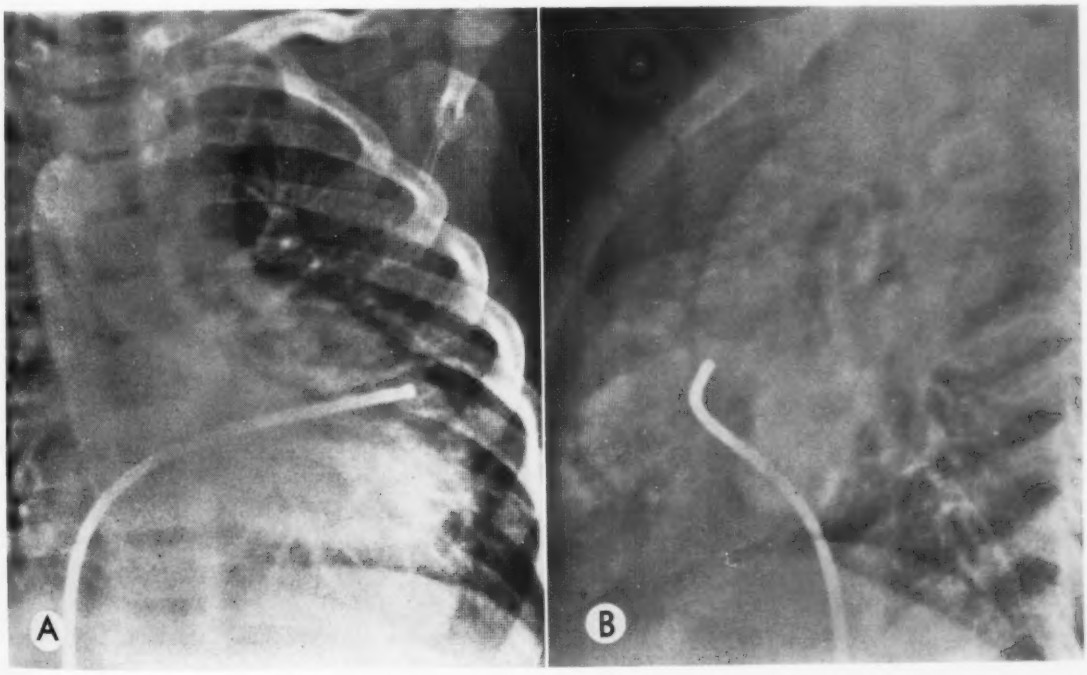

Fig. 9. Case IV. (*A* and *B*) Exposure No. 31 shows that despite previous loss of one third of miokon through the aorta into the systemic circulation, enough remained in the lesser circulation to fill the left atrium, left ventricle and aorta. Note the left to right flow through the interventricular defect.

TABLE III

COMPLICATIONS ENCOUNTERED IN HUMAN STUDIES

	No.	Electrocardiographic Changes	Morbidity	Mortality
left heart puncture	10	10	0	0
angiocardiography only	23	10	0	0
catheterization only	142	110	7	2
selective angiocardiography	159	120	8	0
	334	250	05 (4.5%)	2 (.6%)

Note: Morbidity and mortality in this series appeared not to be associated with angiocardiography. This may be coincidental. Elevation of temperature was considered a sign of morbidity. It was noted in most of the 15 cases.

Lehman or No. 7 Dotter-Lukas catheter. Satisfactory filling of the coronary arteries was noted in 82 per cent of cases.

A monitor cannula placed in the mid or distal portion of the coronary artery showed no abnormal pressure waves and no alteration of normal coronary artery pressure. Momentary dysrhythmias were noted. Serious dysrhythmias, ventricular tachycardia, ventricular fibrillation, and cardiac arrest resulted only on catheterization of either coronary artery or the direct deposition of undiluted contrast medium therein. Two otherwise normal dogs died as a result of this complication.

Twelve dogs had been prepared surgically by insertion of a polyethylene obstruction in the proximal portion of the anterior descending branch of the left coronary artery (Fig. 10, 11, 12 and 13). Three of these dogs died immediately following coronary angiography. No delayed reactions were noted.

The real hazard of this procedure in patients with established myocardial ischemia may be lessened by reducing the amount of contrast medium necessary for good visualization of the vessels. The optimum time of injection should be with the closing of the aortic valves. Perhaps one cycle of opacification will be adequate. Attempts to limit the distribution of the medium by partial aortic obstruction have been helpful.

The benefits and the hazards of this procedure seem potentially so great that intensive efforts to perfect it are indicated.

Reaction to Radiation Exposure. An average dose of 16 r was delivered to the skin of the back over the heart. No direct effect upon the heart could be detected. The reaction of the irradiated area was too slight to be detected, and conservative estimates of future reactions would not be alarming. Treatments directed to the thymus have been considerably greater and are not comparable.

The Coltman tube intensification was used routinely with 0.9 ma. and 70–90 kv. for fluoroscopy. The radiation output was 0.85 r/minute. The usual heart catheterization took five to ten minutes of fluoroscopic time. Biplane angiocardiography

TABLE IV

CORONARY ANGIOGRAMS OF DOGS

good to excellent opacification	15
no opacification	5
fair to poor opacification	7
normal dogs	15
dogs with surgically induced coronary thrombosis	12
deaths	5
normal dogs	1
surgical group	4
mortality rate	14.8%

Note: Poor opacification was noted most frequently in normal dogs where the catheter tip was too high or where the injected dose was too small. Mortality was encountered most frequently in dogs which had received surgical lesions of the coronary arteries.

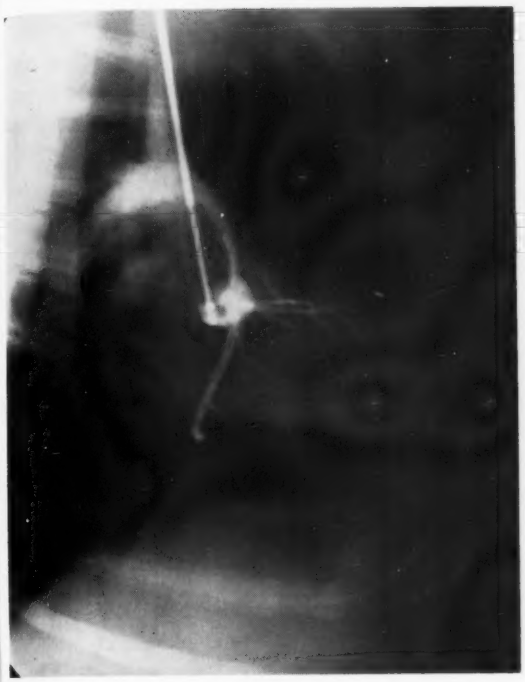

Fig. 10. Coronary angiogram of a dog following experimental occlusion of left anterior descending coronary artery at site of clip. A CO_2 balloon partially occludes the ascending aorta.

Fig. 11. Two tenths second after injection the peripheral branches are well filled with no filling distal to the occlusion.

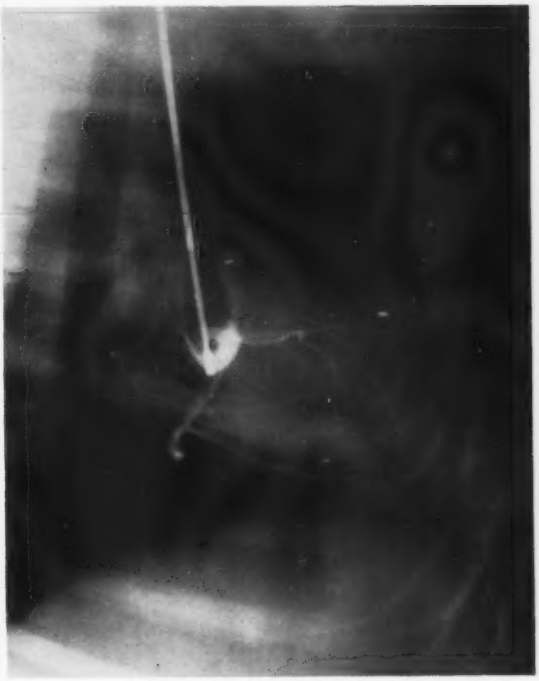

Fig. 12. At four tenths second collaterals have filled up to the distal side of the obstruction.

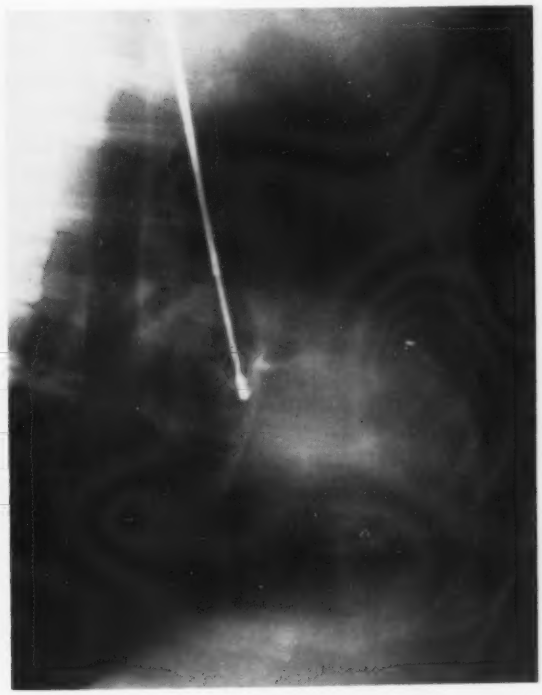

Fig. 13. At six tenths second nearly all of the smaller arteries are clear of the opaque bolus. Only the obstructed segment remains filled.

(Elema) at 90–120 kv., 500 ma., using 1/120–1/10 second exposures was repeated up to thirty-six times for a single series. The shuttering and coning was always sharp. The radiation output for this phase was 5–10 r depending on the size of the patient and the number of exposures.

The gonadal doses have been remarkably low, averaging 0.003 r. This will be reduced further with refinements in technique. The contribution that most of the children in our series might make to the "genetic pool" is very questionable. Most are not likely to live until maturity and those who do are usually chronic invalids and would not be apt to have children.

DISCUSSION

Permanent cardiac arrest, undoubtedly the most striking physiologic aberration possible, was not seen in our series of 159 selective angiocardiographies. Most of our patients were infants and children. In his 1950 review of 23 fatalities due to angiocardiography, Dotter found 19 of the patients to be less than fourteen years of age. Most of our patients (over 90 per cent) fell into this age group. Many were in failure; 4 were newborn infants. Of this latter group 3 were thought to have physiologic neonatal right ventricular hypertension. Two of our patients died shortly after cardiac catheterization. Both of these had severe valvular stenosis, one of the pulmonary valve, the other of the aortic valve. Another child with a similar degree of pulmonary valvular stenosis was treated by emergency valvulotomy and has done well since.

Slight morbidity was associated as often with heart catheterization as with selective angiocardiography. This morbidity could be attributed to these procedures and in part to the basal anesthetic used for infants and young children.

The concurrent studies of cardiac activity disclosed no significant abnormalities attributable to the use of a "high pressure" injector of the Gidlund type. The actual force of delivery at the end of the catheter is approximately 1/1000 of the force applied. The rapidity of such injections permits the use of smaller quantities of contrast materials with an associated reduction of toxicity. Opacification is as good and is more discrete than with the more prolonged intravenous injections.

The experiments in which catheters were allowed to remain in dogs' hearts for over an hour disclosed that some damage was done by the catheter alone. Although no such findings have been noted in humans, it seems advisable to limit the procedures so that the catheter remains in the heart no more than forty-five minutes.

Optimal physical factors depend on the size of the patient, the size of the cardiac chamber to be filled, the pulse rate, and the blood pressure. For the type of patient most frequently seen, *i.e.*, a 15 kg. child with tetralogy of Fallot and a pulse rate of 110, the following factors should suffice: (a) No. 7 catheter tip in the mid-right ventricle; (b) patient set up for anteroposterior and lateral projections; 10×12 cm. field; (c) 16 cc. of miokon 50 per cent contrast agent in automatic syringe (1 cc. for catheter volume); (d) 5 kg./cm.^{2} of air pressure on the Gidlund syringe; (e) 1.5 second injection; (f) 500 ma., 90 kv. peak, 1/120 second exposure; and (g) 6 exposures/second for two seconds and then 2 exposures per second for three seconds.

Such an arrangement results in sharp opacification of the right ventricle. A ventricular septal defect is momentarily visualized and on many occasions can even be measured. The pulmonary arteries are filled shortly before opacification of the aorta. A large amount of the opacified ventricular content enters the systemic circulation, thus diminishing the density of the left atrium and left ventricle. Frequently these are dense enough to demonstrate recirculation, however, and additional information is thus gained.

Coronary angiography seems to be a practical procedure. The demands of cer-

tain surgeons for definitive mapping of coronary filling and of defects in filling can now be met.

CONCLUSIONS AND SUMMARY

1. Clinical and experimental evidence gives no additional support to apprehensions concerning selective angiocardiography.

2. Difficulties in catheterization and ways to avoid them are enumerated.

3. The physical factors of injection are discussed and a recommended technique is outlined.

4. The newer contrast media employed (miokon 50 per cent, 123 cases; hypaque 50 per cent, 36 cases), seem less toxic than those used in earlier studies.

5. Radiation damage to the heart and to the genetic pool is not remarkable.

6. Experimental coronary angiography is a reproducible procedure with diagnostic and surgical promise.

7. One hundred and fifty-nine human cases are reported without fatality or significant sequelae.

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COR TRIATRIATUM SINISTRUM*

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COR triatriatum sinistrum is a rare congenital anomaly in which a fibromuscular septum divides the left atrium into two chambers. The septum also separates the opening of the pulmonary veins from the mitral orifice. The recognition of this condition is of clinical importance due to the feasibility of operative correction. It is the purpose of this paper to review the pertinent literature and to add a case report.

An anomalous septum of the left atrium was originally mentioned by Andral[2] in 1829 in his text on pathologic anatomy. It was fully described for the first time by Church[8] in 1868. Twenty-six additional cases have been reported since that time. The only case diagnosed *in vivo* was reported in March, 1957 by Barrett and Hickie.[5] Pedersen and Therkelsen,[32] in 1954, recorded 23 cases of abnormal cords or bands in the left atrium; however, these are probably harmless since they do not cause an obstruction to the blood flow from the lungs.

Cords and bands have also been reported in the right atrium by Yater,[44] Sternberg,[39] and Ruggieri.[37] An anomalous septum within the right atrium causing reduplication of the atrial chamber was described by Dubin and Hollinshead.[11] Gombert,[16] in 1933, published a case of division of the right atrium by an intra-atrial septum associated with hypoplasia of the right ventricle, atrium, and pulmonary artery. An anomalous accessory median atrial chamber which communicated with both atria was described by Patten and Taggart[31] in 1929.

NOMENCLATURE AND NATURE OF THE LESION

The term "cor triatriatum" was first used by Borst[7] in 1905. Since an anomalous septum is about ten times more common in the left atrium than in the right, many authors (Parsons,[30] Barnes and Finlay,[4] Doxiadis and Emery,[10] Pedersen and Therkelsen,[32] Hartmann,[21] and Barrett and Hickie[5] have applied the term only to division of the left atrium. Properly the term "cor triatriatum" should be used for all types of congenital triatrial heart, and the term "cor triatriatum sinistrum" should be applied to congenital division of the left atrium. This term, "cor triatriatum sinistrum," was first used by Cottier and Tobler.[9]

In cor triatriatum sinistrum the anomalous transverse diaphragm divides the left auricle into two chambers, a dorsocranial chamber which receives the pulmonary vein and a ventrocaudal chamber which opens into the auricular appendage and the mitral orifice. The upper (dorsocranial) chamber is usually larger and its endocardium is thickened. The chambers communicate through one or more perforations in the septum which are variable in location. The size of these openings may also vary from a pinhole to such a large opening that there is no appreciable obstruction to the pulmonary circulation.[23,34,40,41] Pedersen and Therkelsen[32] and Barrett and Hickie[5] mentioned small calcareous deposits at the borders of the perforations. Hartmann[21] also reported calcification in the wall of the upper chamber of the left atrium. Areas of endocardial fibroelastotic change in the upper chamber, pulmonary vein, and mitral valve were described by Doxiadis and Emery[10] in their case.

The common associated congenital defects are patent foramen ovale and atrial septal defect. In the literature 3 cases with the additional finding of abnormal drainage of the pulmonary veins (Stoeber,[40] Patten and Taggart,[31] and Becu *et al.*[6]) and 2 cases

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of tetralogy of Fallot (Preisz[35]) have also been published.

The effect on the circulation in this condition is physiologically similar to that observed in mitral stenosis. The life expectancy appears to be correlated with the size and completeness of the anomalous septum, the size and number of perforations in the septum, the presence and size of a patent foramen ovale, and the presence and severity of other associated defects. Review of the literature reveals that most patients died during infancy, usually within the first four months of life, and in this group of patients the perforation in the septum was always single and small; usually 5 mm. in diameter or less. On the contrary, the patients with fairly large openings, 10 mm. in diameter or more, usually reached maturity. Loeffler's[25] case of congenital triatrial heart was found incidentally at necropsy of a seventy year old Negro woman who died with a clinical diagnosis of hypertensive heart disease and decompensation.

Although there are numerous theories[2,7,10,12,15,18,25,26,27,30,33,45] as to the embryologic nature of the intra-auricular septum, the suggestion by Griffith[18] that it represents the failure of the common pulmonary vein to be incorporated into the left atrium seems most acceptable at present.

REPORT OF A CASE

G.J. was a five year old white male, who was admitted to Emory University Hospital on April 7, 1957 for evaluation of congenital heart disease which had been known to be present since one year of age. The child was born following an uneventful pregnancy and was a full term delivery. He developed normally until approximately six months of age when the parents first noticed some difficulty in his breathing and that he tired easily. However, he continued to do fairly well until one year of age, when he developed chicken-pox. At this time the family doctor discovered evidence of cardiac abnormality and referred him to a cardiologist. No conclusive diagnosis was established.

The patient began to suffer from repeated upper respiratory infections, dyspnea became more prominent and he tired more easily. At the age of two he began to have brief periods of syncope with cyanosis. These cyanotic episodes at first occurred two to three times per day, but gradually decreased in frequency to one episode every two to three weeks. Squatting had been noted since the age of two. At the age of four years, he developed edema of his ankles, feet, and periorbital tissues. At the time of admission to Emory University Hospital, dyspnea was severe.

On physical examination the child appeared to be underdeveloped for his age. He weighed 35 pounds. No definite cyanosis was noted at rest. A few petechiae were seen in the left conjunctiva. The lungs were clear. There was prominence of the left anterior chest wall with systolic propulsion. By percussion, the heart was enlarged to the left anterior axillary line. A Grade II systolic murmur was heard best at the left sternal border in the third and fourth intercostal space and P_2 was loud and split. A Grade I diastolic run-off was heard, at first well localized in the third intercostal space, but later down the left sternal border to the apex. The liver was enlarged and palpable 2 cm. below the right costal margin and the spleen was easily felt on inspiration. The electrocardiogram (Fig. 2) revealed right ventricular hypertrophy and strain.

Roentgen examination (Fig. 1) showed a markedly enlarged heart with evidence of right atrial and right ventricular enlargement, but there was no evidence of left atrial enlargement. Marked pulmonary congestion and edema were also seen. There was no demonstrable hilar dance with the aid of the image amplifier. A markedly prominent pulmonary artery segment and enlarged hilar branches of pulmonary artery were seen; however, the peripheral vessels were not dilated. Follow-up studies after two weeks showed no significant changes.

A tentative clinical diagnosis of atypical patent ductus arteriosus with reverse flow was made and an exploratory thoracotomy was performed on April 26, 1957. A patent ductus arteriosus was not present. The ligamentum arteriosum was identified, ligated and severed. Pulmonary hemosiderosis was noted and the pulmonary artery was markedly dilated, measuring about twice the diameter of the aorta. Since no obvious correctable defect could be identified, intracardiac pressure was taken and the chest was closed. The patient expired five hours later.

Postmortem Findings. The heart weighed

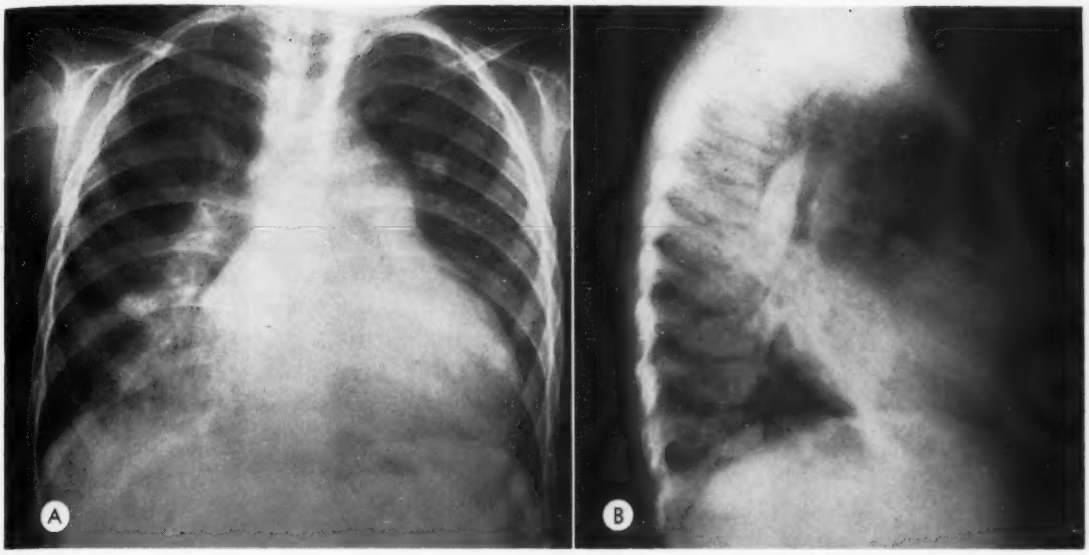

Fig. 1. (*A*) Posteroanterior and (*B*) lateral chest roentgenogram. There is an enlarged heart with marked enlargement of pulmonary artery and hilar branches, right ventricle, and right atrium. Pulmonary congestion is also evident. There was no evidence of left atrial enlargement or of hilar dance at fluoroscopy.

250 gm. (normal 85 gm.). The right atrium was tremendously enlarged (approximately three times the size of the left atrium), and the right ventricle also showed marked hypertrophy (twice the size of the left ventricle). The pulmonary veins had a normal distribution, but were markedly enlarged. The pulmonary artery also appeared to be enlarged and showed arteriosclerotic changes. The foramen ovale was anatomically closed and no interatrial defect was found. The tricuspid, aortic and pulmonary valves were normal. The coronary arteries had normal distribution. The left atrium had a cylindrical shape, measuring 3.0×1.5 cm. in size, and was divided into two chambers; a large craniodorsal and a small ventrocaudal chamber, by a complete fibrous diaphragm which was separating the left auricular appendage and mitral valve from the pulmonary veins (Fig. 3). The only communication through the septum was a small opening, measuring 5 mm. in diameter. The mitral valve was intact.

ROENTGEN FINDINGS

The roentgen findings of cor triatriatum were first described by Patten and Taggart[31] (1929) in their case with an accessory median atrial chamber and the first roentgenographic findings of cor triatriatum

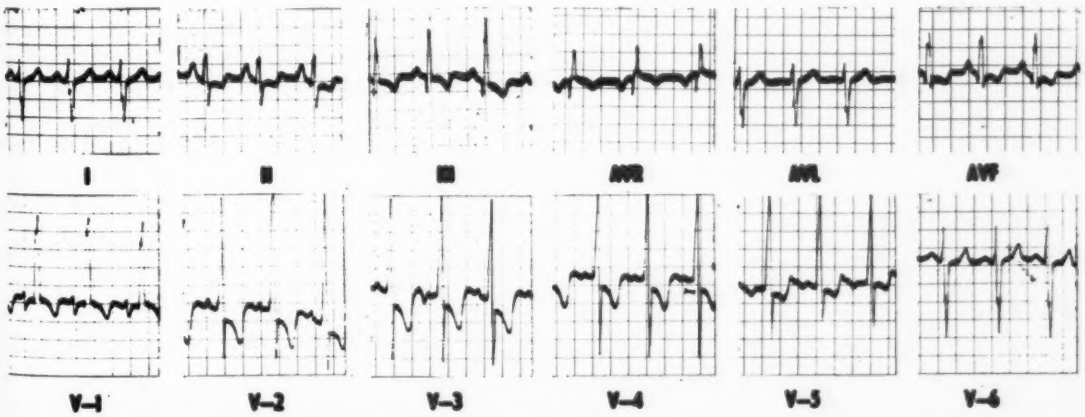

Fig. 2. Electrocardiographic tracings shows right ventricular hypertrophy and abnormal P waves.

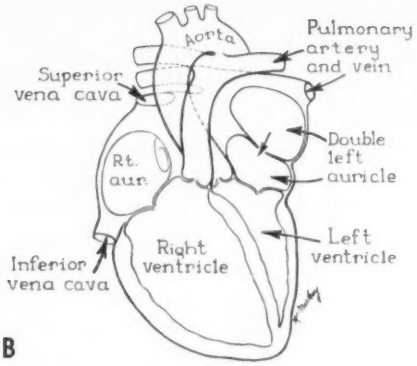

FIG. 3. (*A*) Intra-atrial septum viewed from the ventrocaudal chamber of the left atrium showing a 5 mm. opening. (*B*) Diagram of the heart in cor triatriatum sinistrum.

sinistrum were reported by Palmer[29] in 1930. No roentgenographic findings have been recorded in double right atrium.

In 13 cases the roentgenograms of the chest were published and the roentgenographic findings are listed in Table 1. The present case showed cardiac enlargement with evidence of right atrial and right ventricular enlargement. The left atrium was not enlarged. There was marked prominence of the pulmonary artery segment and the primary branches of the pulmonary artery were dilated, but no hilar dance was demonstrated with the image amplifier. Marked pulmonary congestion and edema were also present. Review of the chest roentgenograms in 13 cases revealed that the roentgen findings are noncharacteristic. However, a prominent pulmonary artery segment is almost always present in all patients. Dilated hilar branches of the pulmonary artery and right ventricular enlargement are also frequent features. The lung fields usually show pulmonary congestion or edema. Enlargement of the left atrium was reported only in 2 cases (Hartmann,[21] Barnes and Finley[4]) and on postmortem examination enlargement of the left atrium was not a frequent or characteristic finding in these patients.

The degree of cardiac enlargement and pulmonary congestion on roentgenograms depends on the size and number of the perforations in the intra-atrial septum. Though small calcareous deposits in the border of the perforation and calcification in the wall of the upper chamber of the anomalous left auricle are mentioned in the literature, no intracardiac calcifications have been observed on the chest roentgenograms.

CLINICAL SYMPTOMS AND SIGNS

Respiratory embarrassment secondary to congestion with subsequent right ventricular failure is the most prominent feature of all cases with symptoms. Cyanosis is absent or only intermittent until the patient succumbs to rapidly developing cardiac failure. Recurrent respiratory infections and repeated hemoptyses are also recorded. Tachycardia, sometimes with cardiac irregularity, is usual. Cardiac enlargement may be present. In very young infants, the clinical symptoms begin with feeding difficulty and frequent vomiting and subsequently evidence of heart failure.

The stethoscopic findings have been no more conclusive. Systolic murmur is frequent; however, a diastolic murmur and even no murmur has been reported in the several patients. In most of the cases the pulmonary second sound is accentuated.

Electrocardiography was first reported by McLester *et al.*[27] and has been recorded in 7 patients in the literature. The electrocardiogram always revealed right ventricular hypertrophy and an abnormal P wave on occasion.

Cardiac catheterization has only been re-

TABLE I

ROENTGEN FINDINGS AND POSTMORTEM FINDINGS IN 13 CASES

Authors	Sex	Age	Roentgen Findings		Postmortem Findings		
			Heart	Lungs	Size of Perforation in Diaphragm	Heart and Great Vessels	Complications
Patten and Taggart[31] (1929)	F	1 3/12 yr.	Globular enlargement	Hilus showed increased shadows (congestion)	Small	Right ventricle and pulmonary artery enlarged	Patent ductus arteriosus. Small interatrial septal defect
Palmer[29] (1930)	M	3/12 yr.	Marked enlargement		6 mm. in diameter	Right ventricle and pulmonary artery enlarged	Large patent foramen ovale and patent ductus arteriosus
McLester, Bush and DuBois[27] (1940)	M	18 yr.	No cardiac enlargement. Slight bulge in the cardiac outline in the region of the left auricular appendage		Two: 2×5 mm. 3×5 mm.	Right ventricle enlarged. Left atrium small	
Pfennig[33] (1941)	F	1/12 yr.	Globular enlargement		Size of thin probe	Right ventricle and pulmonary artery enlarged. Left ventricle small	Patent ductus arteriosus
Parsons[30] (1950)	M	2/12 yr.	Generalized enlargement of heart shadow and fullness of left upper border	An area of consolidation at the right lung root	Size of a pin	Greatly enlarged right ventricle and considerably enlarged left atrium	Patent foramen ovale. Hypoplastic mitral valve
Edwards *et al.*[12] (1951)	F	6/12 yr.	Progressive enlargement of the heart (within 1½ mo.)		3 mm. in diameter	Right atrium and right ventricle enlarged	Patent foramen ovale
Barnes and Finlay[4] (1952)	M	1 yr.	Progressive cardiac enlargement. Probable relative left atrial enlargement	Pulmonary congestion and edema	2 mm. in diameter	Right ventricle, pulmonary artery and left atrium enlarged. Left ventricle small	
Doxiadis and Emery[10] (1953)	F	10 wk.	Large heart with prominent pulmonary artery	Mottling in both lung fields, particularly in upper lobes	2×3 mm.	Right ventricle enlarged	Patent foramen ovale. Endocardiac elastofibrotic changes in upper chamber at left auricle and pulmonary vein
Pedersen and Therkelsen[32] (1954)	F	29 yr.	Normal cardiac size (cardio-thoracic ratio 13:26.5). Prominent pulmonary artery	Pronounced pulmonary congestion, emphysematous left lower lobe and signs of a previous pleurisy	5×7 mm.	Right ventricle enlarged	
Becu *et al.*[6] (1955)	F	5/12 yr.	Cardiac enlargement	Considerable increase in the pulmonary vascular markings	11 mm. in diameter	Right ventricle enlarged	Anomalous connection of pulmonary vein with narrowed left lower pulmonary vein
Hartmann[21] (1955)	M	12 yr.	Left auricular enlargement suggestive of right ventricular enlargement	Prominent pulmonary vessels	5×6 mm.	Right ventricle, right atrium and left atrium enlarged	
Cottier and Tobler[9] (1957)	M	4/12 yr.	Right ventricular enlargement. Apex is elevated	Pulmonary congestion, enlarged right upper mediastinal shadow suggesting dilated superior vena cava	4 mm. in diameter	Right ventricle and right auricle enlarged	
					Operative Findings		
Barrett and Hickie[5] (1957)	M	17 yr.	Right ventricular enlargement. Enlarged pulmonary arteries		10×5 mm.	Pulmonary artery and pulmonary vein dilated. Left atrium enlarged	
Authors' Case (1957)	M	5 yr.	Markedly enlarged heart with evidence of right atrial and ventricular enlargement. Prominent pulmonary artery segment	Marked pulmonary congestion and edema. Dilated hilar branches of pulmonary artery	5 mm. in diameter	Right auricle and right ventricle enlarged. Pulmonary vein dilated	

ported in 2 patients. Pulmonary hypertension and an elevated pulmonary capillary wedge pressure suggesting mitral stenosis were found in both cases.

No angiocardiography has been reported, but should show retained contrast medium in the left atrium similar to that of mitral stenosis.

DIFFERENTIAL DIAGNOSIS

In infancy the malformation is to be differentiated from other conditions which cause cardiac enlargement and cardiac failure, especially with obscure pulmonary hypertension. Chief among the conditions to be considered are: (1) congenital valvular disease (mitral stenosis or less likely Ebstein's anomaly of the tricuspid valve or Lutembacher's syndrome); (2) primary myocardial disease (endocardial fibroelastosis, von Gierke's disease, anomalous origin of left coronary artery from the pulmonary artery and Fiedler's myocarditis); (3) anomalous pulmonary venous drainage into the coronary sinus or directly into the right auricle; (4) patent ductus arteriosus with reversal of flow; and (5) acquired mitral stenosis in older patients.

SUMMARY

A case of cor triatriatum sinistrum is reported with a review of the anatomy, embryology, and the clinical and particularly the roentgen features of this malformation. A brief discussion of the nomenclature and the differential diagnosis is presented. This condition is physiologically similar to mitral stenosis and surgically curable if the diagnosis is made *in vivo*.

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THE RELATIONSHIP OF SYSTEMIC VENOUS ANOMALIES TO THE PARAVERTEBRAL VEINS*

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THE functions of the vertebral venous system and its roentgenologic anatomy in man have been summarized in a number of recent papers.[1-5] Our interest in this venous system was stimulated some years ago following a series of angiocardiographic injections through the saphenous or femoral veins. The degree of filling of the vertebral vessels was striking. Analysis of 40 sequential studies in patients below the age of four showed significant opacification of the vertebral and azygos systems in about two-thirds of the cases.[1]

These studies of the venous return to the heart yielded some remarkably clear roentgenologic demonstrations of normal anatomy (Fig. 1, *A* and *B;* Fig. 1, *C* and *D;* and Fig. 1, *E* and *F*).[1] Of equal interest was the number of variations in venous pattern noted. These were observed following injection of veins in both upper and lower extremities. Among the anomalies demonstrated were not only the common left superior vena cava,[14] but also absence of the inferior vena cava,[3] drainage of the hemiazygos vein into a left superior vena cava, absence of the cephalad portion of the superior vena cava, absence or hypoplasia of the innominate vein, drainage of the venae cavae and the hemiazygos vein into the left atrium,[9] and many other minor variations. A description of some of these variations illustrates the alternative pathways of systemic venous return to the heart.

Absence or hypoplasia of the left innominate vein is an anomaly in which blood from the left upper extremity and the left jugular veins cannot reach the superior vena cava and right atrium through the usual channels. The opaque medium injected in the left antecubital vein may flow into the left superior intercostal vein, thence into the accessory hemiazygos and the azygos veins, and finally into the superior vena cava (Fig. 2).* A portion of it may enter the paravertebral plexuses, cross the spine, and reach the superior vena cava through collateral channels. The course followed by blood from the upper extremity is similar to that found in the presence of left innominate vein obstruction. As an alternate pathway, we have observed flow from the left subclavian vein through a large superior intercostal vein into the accessory hemiazygos vein, the vertebral veins, the inferior vena cava via anastomotic channels, and finally into the caudal portion of the right atrium. In this way, blood from the upper part of the body detours to the great caval vein draining the lower portion of the body.† An additional avenue of return in this anomaly is through a left superior vena cava into the coronary sinus of the right atrium. There is a number of other available pathways,[11] and the intracranial venous sinuses may participate in the collateral system when an innominate vein is obstructed.

If the inferior vena cava is occluded, blood from the lower extremities may reach the heart through the paravertebral and azygos systems. If the inferior vena cava is congenitally absent, the same avenues will be utilized. Figure 3, *A* and *B* demonstrates a huge hemiazygos vein as the major channel from the abdomen, emptying into the superior vena cava and

* In a similar case described in the literature, the left superior intercostal vein is not identified as such but is called a left innominate vein.[13]

† Since these patients were in horizontal position, gravity was not a factor in the transit of the opaque medium to the inferior vena cava.

* From the Department of Radiology, Stanford University School of Medicine, San Francisco, California. Presented at the Fifty-eighth Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 1–4, 1957.

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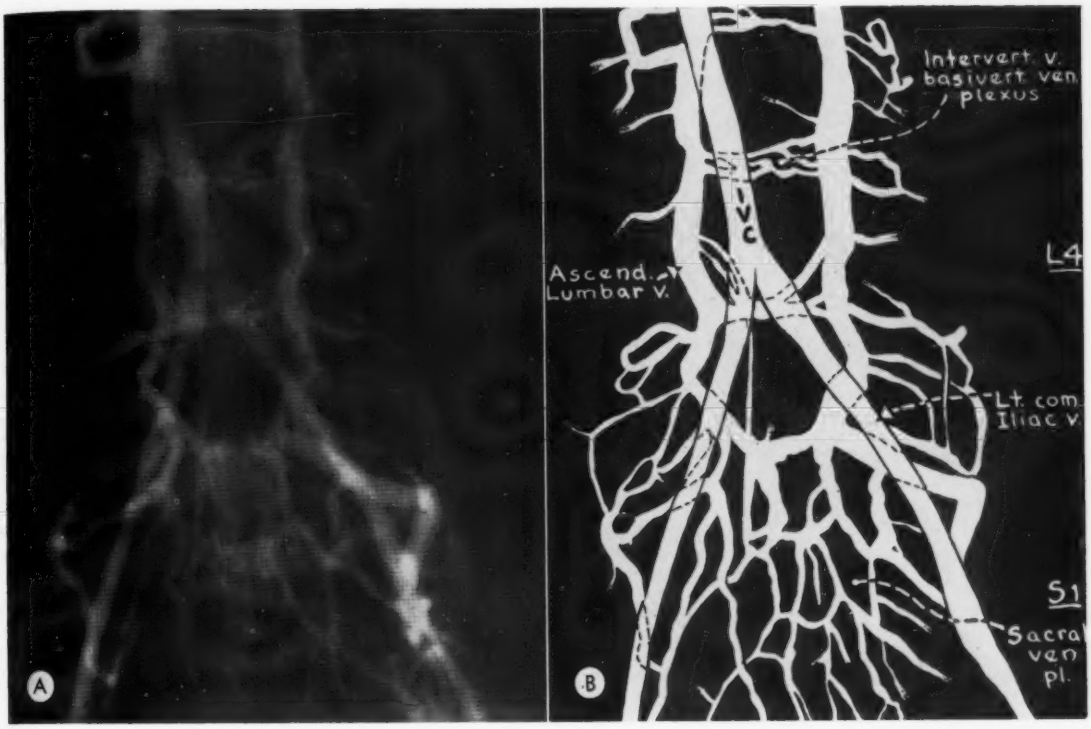

Fig. 1. The vertebral venous plexuses. (*A* and *B*) Sacral and lower lumbar levels. The plexiform character of the vertebral veins and profuseness of their ramifications are illustrated in this study. The ascending lumbar channels are occasionally large and almost equal in size to the inferior vena cava, as in this case.

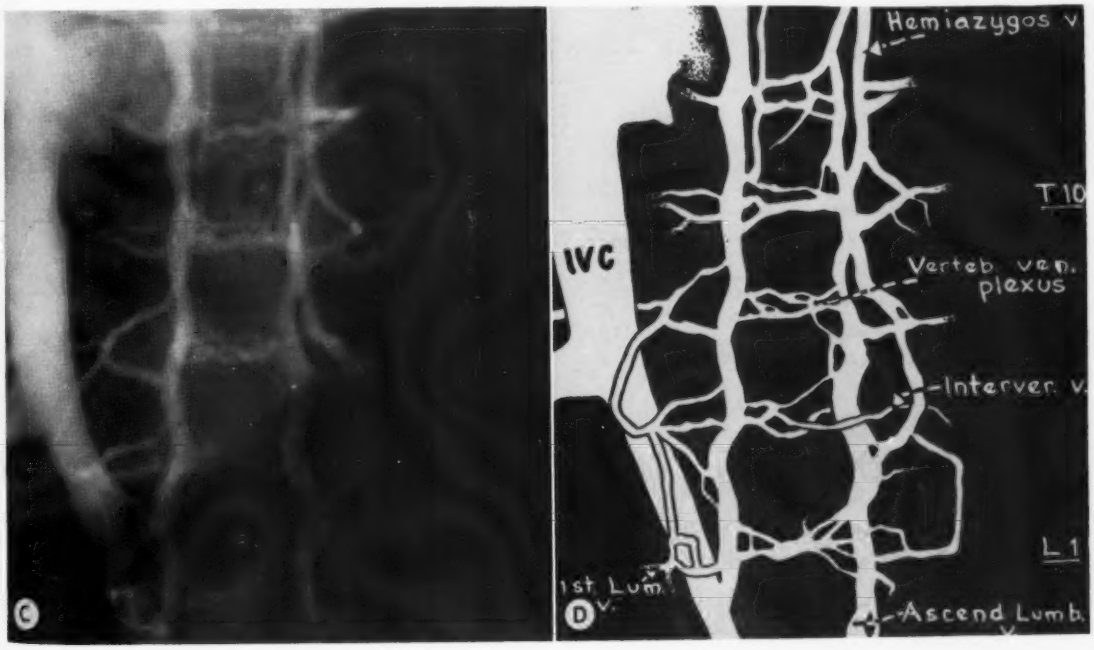

Fig. 1. The vertebral venous plexuses. (*C* and *D*) Lower thoracic level. At this level, the vertebral veins are similar to those in the lumbar area, and now drain into the intercostal veins, which in turn empty into the hemiazygos and azygos channels.

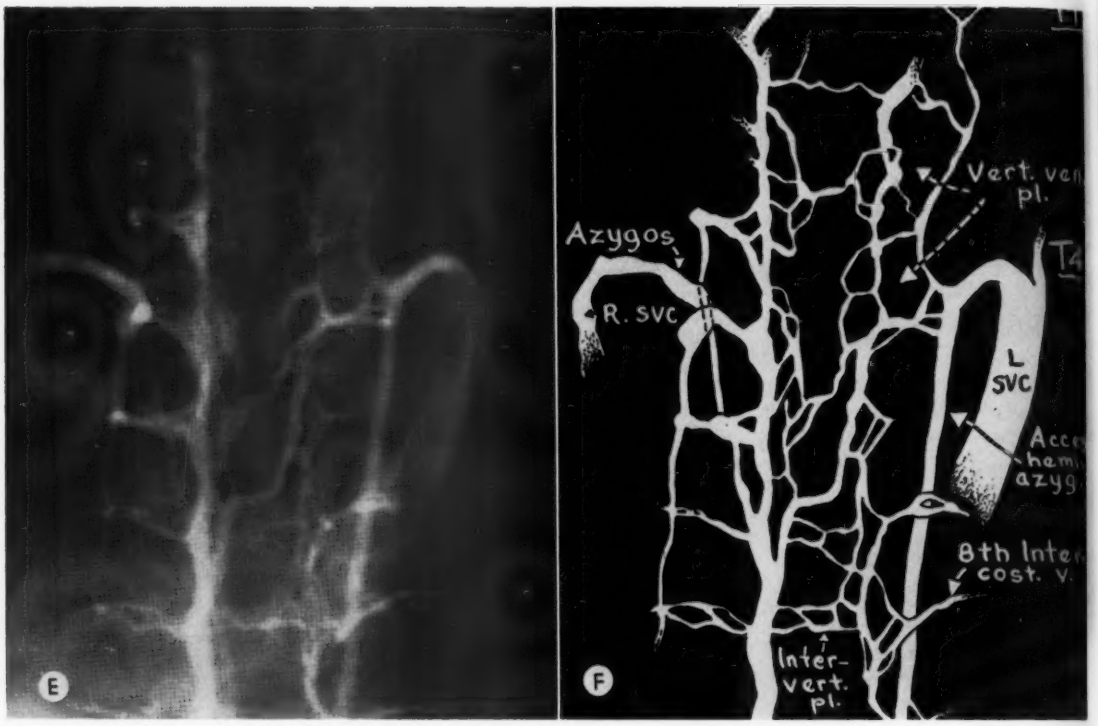

FIG. 1. The vertebral venous plexuses. (*E* and *F*) Upper thoracic level. The vertebral venous plexuses are opacified following the injection of the opaque medium into the left saphenous vein. The primitive paired arrangement of both the azygos and superior vena caval veins is preserved, the accessory hemiazygos emptying into the left superior vena cava (LSVC), and the azygos into the right superior vena cava (RSVC). The medial portions of the intercostal veins are opacified.

thence into the right atrium. The hemiazygos may also empty into a left superior vena cava, which communicates with the right atrium through the coronary sinus. At least 24 cases of so-called "absence of the inferior vena cava" have been reported in the literature.[3,7,8,11,12] The term is somewhat of a misnomer, since it is usually only the hepatic portion of the inferior vena cava which is absent. In the reported cases, the venous drainage of the inferior vena cava reached the heart through the azygos and superior vena caval systems.

Rarely, one or both of the venae cavae may enter the left atrium.[2,6,9,10,13] In these cases, the return of the systemic venous blood to the left heart produces definite peripheral arterial oxygen unsaturation. If the inferior vena cava is absent, hemiazygos venous drainage into the left atrium may also be observed (Fig. 4, *A*, *B* and *C*).

DISCUSSION

Batson's concept of the vertebral venous system as a large, low-pressure, intercommunicating reservoir of blood, in which alterations in pressure and direction of flow may occur,[4,5] receives some support from the present studies. In each of these studies, the patient was supine and had no pressure applied to the inferior vena cava or the abdomen. Yet, injection into the saphenous or femoral vein was frequently followed by opacification of the vertebral and azygos venous systems. In some instances, the opaque medium traveled well above the termination of the azygos vein as high as the level of the first thoracic vertebra (Fig. 1, *E* and *F*). Since the venous drainage from the upper thorax normally runs caudad towards the right atrium, a reversal of direction of flow must be presupposed. It may also be demonstrated that opacified

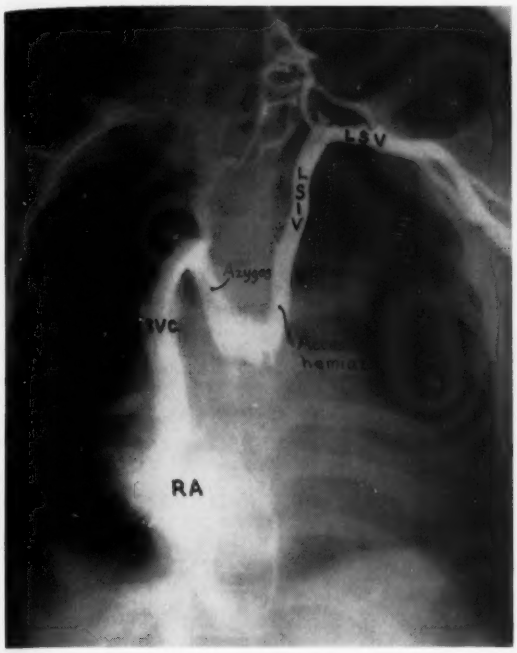

Fig. 2. Agenesis of the left innominate vein. The opaque medium, injected into the left brachial vein, opacifies the left subclavian vein (LSV) and then flows through the left superior intercostal vein (LSIV) to reach the accessory hemiazygos vein. It then joins the azygos flow, and finally reaches the superior vena cava (SVC). Note that there is also filling of some of the paravertebral veins in the lower cervical and upper thoracic region.

blood from the left upper extremity travels through the azygos and paravertebral route into the abdomen, reaches the inferior vena cava, and then ascends into the right atrium.

The dependence of the systemic venous circulation on the vertebral and azygos systems when normal channels are occluded or absent is well illustrated by these cases. If the inferior vena cava is absent, blood from the lower portion of the body reaches the right atrium from above, entering the superior vena cava from the azygos

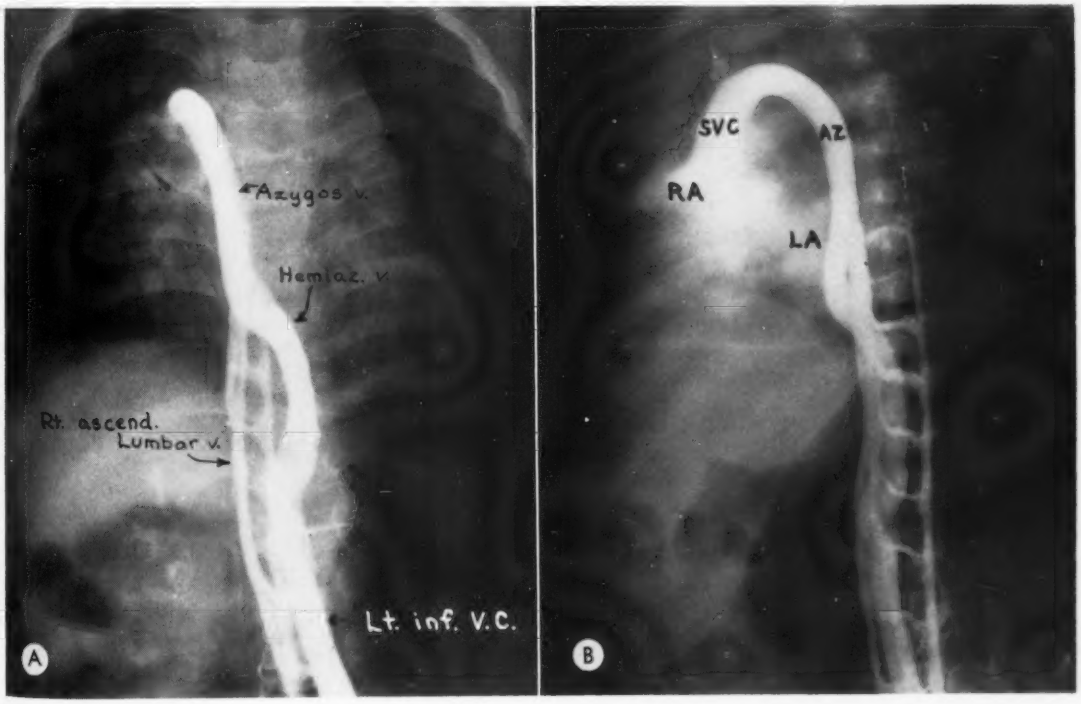

Fig. 3. Absence of the inferior vena cava. The hepatic portion of the inferior vena cava is absent, and the opaque medium has flowed into the hemiazygos vein, thence into the azygos vein. The hemiazygos is a large channel, and is continuous with the left inferior vena cava, and thus blood from the lower extremities and abdomen reaches the right atrium. (*A*) Anteroposterior view. (*B*) Steep right posterior oblique view.

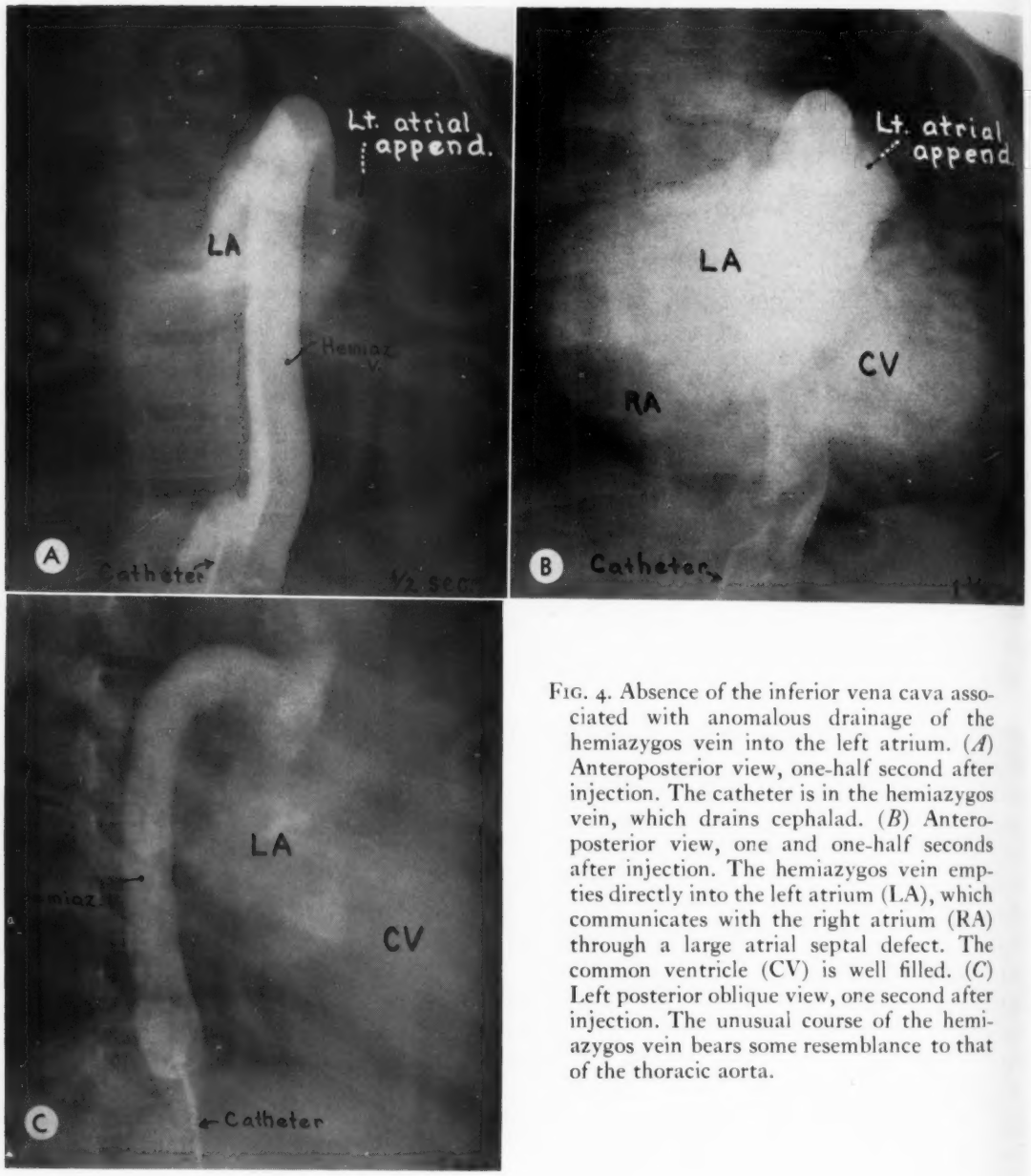

FIG. 4. Absence of the inferior vena cava associated with anomalous drainage of the hemiazygos vein into the left atrium. (*A*) Anteroposterior view, one-half second after injection. The catheter is in the hemiazygos vein, which drains cephalad. (*B*) Anteroposterior view, one and one-half seconds after injection. The hemiazygos vein empties directly into the left atrium (LA), which communicates with the right atrium (RA) through a large atrial septal defect. The common ventricle (CV) is well filled. (*C*) Left posterior oblique view, one second after injection. The unusual course of the hemiazygos vein bears some resemblance to that of the thoracic aorta.

system after traversing the vertebral and ascending lumbar veins. If the innominate vein is small or atresic, blood from the left upper extremity may reach the right atrium from above, via the azygos system and the superior vena cava, or from below, utilizing the azygos veins, the vertebral veins, and the inferior vena cava.

In most instances, little clinical significance is attached to the variations in venous return. Occasionally, however, knowledge of these variations may have important practical implications. In one instance in which the hepatic portion of the inferior vena cava was absent and the venous drainage from the abdomen reached the right atrium through the azygos system and the superior vena cava, ligation of the azygos vein was followed by retroperitoneal hemorrhage and death.[8] A major dual system of

venous return from the lower portion of the body did not exist in this patient. Awareness of this possibility might have forestalled the surgical procedure.

In the approach to ligation of the inferior vena cava for pulmonary embolism, the failure to find the vessel, or the finding of a small vessel on the right side, should suggest the possibility of persistent left inferior vena cava. In the presence of portal hypertension, a portacaval shunt might be difficult or impossible if a left inferior vena cava were continuous with the hemiazygos vein. Furthermore, the portal blood flow would be shunted directly into the anastomotic system, which builds up as a response to portal hypertension.

Where such an anomaly as vena caval insertion into the left atrium exists and causes cyanosis, surgical correction may be undertaken if the anatomy is clearly outlined.[10]

Finally, a knowledge of some of the variations in venous anatomy may occasionally explain unusual clinical findings. Thus, it is not difficult to visualize unilateral development of a chest wall collateral circulation due to superior vena caval obstruction in the presence of congenital hypoplasia or absence of the innominate vein; in such a situation, a route for left upper extremity blood to reach the inferior vena cava via the paravertebral and azygos veins has already been established. The cardiac physiologist, too, should be aware of the variations that occur; following cardiac catheterization through the saphenous vein, the unusual course taken by the catheter in the absence of an inferior vena cava may otherwise be a vexing source of puzzlement.

SUMMARY AND CONCLUSIONS

Following the injection of opaque medium into the saphenous or femoral vein in infants, opacification of the vertebral and azygos venous systems was noted in about two-thirds of 40 cases. The ease with which the vertebral veins may be opacified and the extent of opacification at times observed support Batson's concept that the direction of flow of blood in the vertebral veins may be reversible. Many variations in the anatomy of the systemic venous return occur, in a number of which the vertebral and azygos systems are used as primary routes of venous return. Systemic venous variations are illustrated and their implications discussed.

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Vol. 80, No. 3

CONGENITAL HYPERTROPHIC EMPHYSEMA

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CONGENITAL hypertrophic emphysema is a rare cause of respiratory distress in infants. It has been previously described under the names of lobar emphysema,[8] lobar obstructive emphysema,[16] congenital lobar emphysema,[14] congenital obstructive emphysema,[5] and localized hypertrophic emphysema.[15] The disease is characterized by lobar pulmonary emphysema of congenital origin. Symptoms appear in the early days or weeks of life. The diagnosis is made by roentgen studies, augmented by endoscopic examination of the tracheobronchial tree. The treatment is surgical. Since the condition is rare, and has been established as an entity only in recent years, it is considered worthwhile to submit an additional case report, and discuss the features of this anomaly.

REPORT OF A CASE

This female infant was first seen in the Out-Patient Department at Fort Benning, at the age of three and one-half months, with the complaint of labored respirations, retraction of the chest, and frequent coughing followed by vomiting. No cyanosis had been noted. The child was normally developed and nourished. The mother had noted chest retractions soon after birth. A heart murmur had been discovered at the age of one month. Physical examination revealed an acyanotic dyspneic child with a respiratory rate of 50 to 70 per minute, accompanied by retraction of the costal margins. There was no fever. There were hyperresonance and diminution of breath sounds over the right chest. The chest was barrel-shaped. There was a Grade III apical systolic murmur, accompanied by palpable thrill. The remainder of the examination was negative. The electrocardiogram was interpreted as showing marked right ventricular hypertrophy and possible atrial hypertrophy or dilatation. Examinations of the blood and urine were normal. The clinical impression at that time was interventricular septal defect with pulmonary hypertension.

The initial roentgenogram (Fig. 1) showed extreme radiolucency of the right midlung field, with triangular densities in the upper and lower medial aspects. In lateral view (Fig. 2), the retrosternal clear space was markedly increased, being about 2 cm. wide. Both leaves of the diaphragm were depressed. Aside from apparent rotation and posterior displacement, the heart was not remarkable. The left lung density was normal. At first glance, pneumothorax was considered, but on close scrutiny some faint lung markings could be visualized in the radiolucent area on the right side. A diagnosis was made of obstructive emphysema of a portion o-the right lung, with compression of the remainf ing portions, and mediastinal herniation of the emphysematous portion. Fluoroscopy of the chest revealed very limited motion of both leaves of the diaphragm and mediastinal displacement to the left with no respiratory shift.

The infant was admitted to the hospital one month after her initial visit. Bronchoscopy under ether anesthesia revealed no evidence of obstruction or foreign body. Bronchography (Fig. 3, *A* and *B*) demonstrated a normal bronchial tree in the upper and lower lobes except for crowding and displacement of the bronchi. The middle lobe bronchus could not be filled beyond 1 cm. of its orifice. These films conclusively showed the posterior compression of the upper and lower lobes by the emphysematous middle lobe. The dionosil (oily) was completely absorbed from the lung at the end of three days.

The child's respiratory distress remained unchanged. There was never any evidence of infection. The pulmonary abnormality was now recognized as the infant's primary problem. It was believed that the persistence of the findings without the development of pneumonia or atelectasis ruled out acquired bronchial obstruction, and that the condition must be a congenital one. It was decided that, in spite of the added risk from the congenital heart disease, lobectomy should be undertaken.

Right middle lobe resection was carried out on July 31, 1956 through an anterolateral thor-

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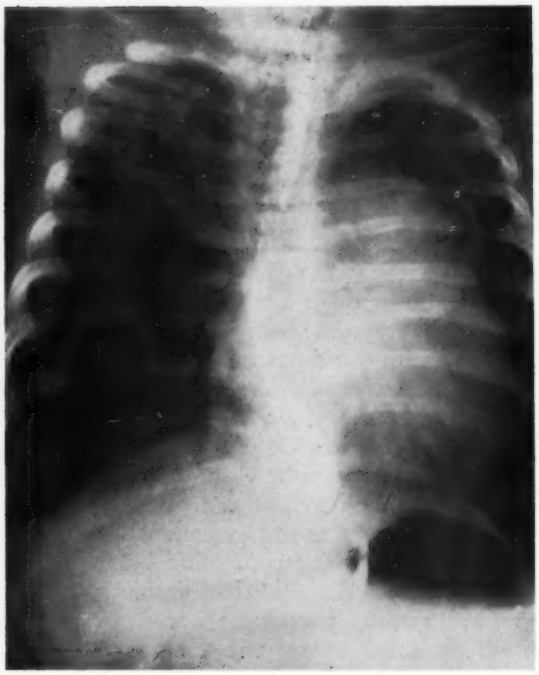

FIG. 1. Compression atelectasis of right upper and lower lobes, clear right midlung field, and left displacement and rotation of the heart.

acotomy incision under endotracheal ether anesthesia. The emphysematous middle lobe herniated through the operative incision. The lobe was of pink homogeneous color and was compressed with great difficulty. The vascular supply to the lobe was normal. The atelectatic upper and lower lobes were easily expanded by the anesthetist to fill the right chest.

Following recovery from anesthesia, the infant's respirations became normal, at 30 per minute, with no retraction of the chest. A postoperative roentgenogram showed return of the mediastinum to the midline, but with slight decrease in the volume of the residual right lung and slight relative emphysema of the left lung.

Examination of the specimen revealed constriction of the segmental bronchi, both medial and lateral, immediately distal to their site of origin from the main stem bronchus of the middle lobe. The constrictions measured 2 and 3 mm. in length, narrowing the lumen to less than 1 mm. in diameter in both segmental bronchi. There were no cysts in the lung, but homogeneous alveolar distention with some rupture of the alveolar walls was present throughout. The bronchial walls were normal, and their caliber and distribution except for the stenotic segments were normal. The elastic tissue stains revealed no abnormality in this tissue. The formalin-fixed lobe measured 9.2×7.0×2.2 cm. and weighed 60 gm.

DIAGNOSIS

Awareness of the entity is important in prompt evaluation. Infants with shortness of breath or difficult breathing, cough, and no history to suggest infection should be suspected. Cyanosis has not been an important factor except in a few cases. The severity of dyspnea may wax and wane. On physical examination, retraction of the chest is noted. There is no fever. Diminished breath sounds and hyperresonance are observed over the emphysematous lobe. There may be a wheeze on the same side. The heart sounds may be distant.

The roentgen examination establishes the diagnosis. The posteroanterior chest roentgenogram shows low flat diaphragm, associated with increased radiolucency of

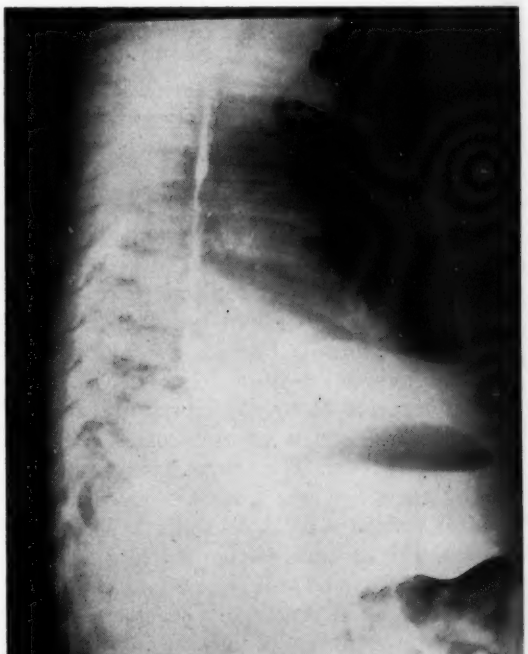

FIG. 2. Barrel-shaped chest and increased retrosternal clear space, produced by herniation of middle lobe across the midline. Mediastinal pleura was intact but displaced about 6 cm. to left at operation.

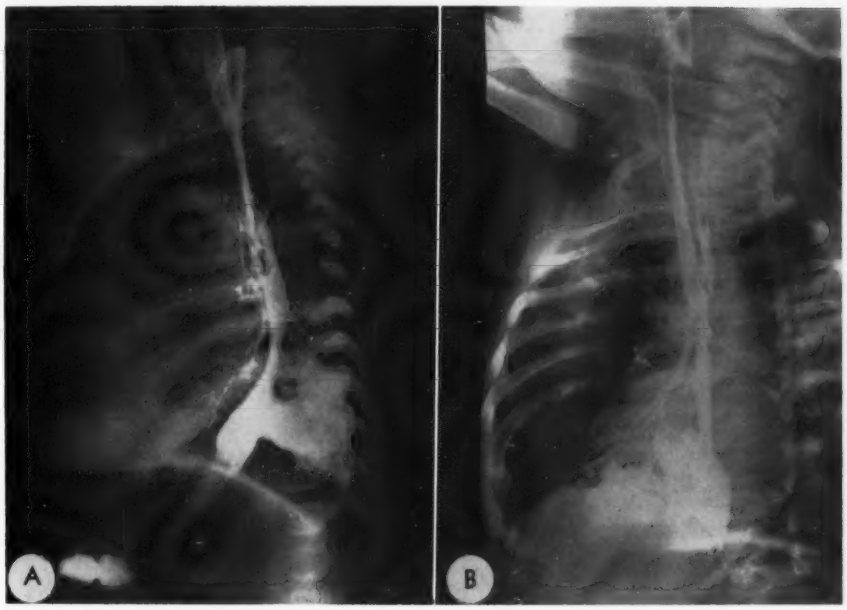

FIG. 3. Bronchograms show posterior compression of upper and lower lobes and nonfilling of middle lobe bronchi. (*A*) Right lateral and (*B*) right posterior oblique (recumbent) views.

one side of the chest. The emphysematous lobe may be almost completely radiolucent, but with good technique and careful scrutiny, lung markings can be seen in the radiolucent area. The remaining lobe or lobes on this side will show varying degrees of compression atelectasis. The configuration of the shadows of these lobes is the same as is seen in atelectasis from other causes, *i.e.*, like a fan closing upward and medially or downward and medially, depending upon the lobe involved. Their margins are not round as is the case when they are compressed by pneumatocele, pneumothorax, or expanding cyst. There is mediastinal shift away from the radiolucent side. This shift in most cases is fixed when observed fluoroscopically, apparently due to the degree of distention of the thoracic cavity, but some cases[16] may show the classic inspiratory shift to the affected side. The motion of the low, depressed diaphragm is limited. There is usually an excessive clear space behind the sternum on lateral view due to herniation of the emphysematous lung across the midline.

The differential diagnosis includes spontaneous pneumothorax, congenital and postinfectious cysts of the lung, pneumonia and atelectasis, enterogenous cysts in the chest, agenesis of the lung, diaphragmatic hernia, and obstructive emphysema due to foreign body or mucus plug. In most cases the findings are distinctive, and the above entities can be ruled out on plain roentgenograms and by fluoroscopic examination. Study of the gastrointestinal tract with barium may be necessary.

Bronchoscopy and bronchography are important in the final assessment of the patient prior to surgery. These procedures will insure that no foreign body is present, establish the normalcy of the remainder of the bronchial tree, and give the surgeon anatomic information important in planning his operation. Bronchography has failed to elicit filling of the affected bronchus in every case in which this procedure was performed,[7,8] but has not been done in most cases. In the cases without obstructive phenomena, it is possible that filling would be obtained.

PATHOLOGY

A single, entire lobe is most frequently affected. Hypertrophic emphysema has

been described in the right middle lobe, the left upper lobe, and the right upper lobe, in that order of frequency. With one or possibly two exceptions, however, it has not been seen in either lower lobe. Henry, in discussing Sloan's[16] article, mentions its occurrence in the superior and lateral basal segments of the right lower lobe. Caffey[4] describes a suspected case, in which operation was not done, with involvement in the left lower lobe.

The parenchymal lung tissue shows distended alveoli, with some breakdown of their walls and coalescence into larger sacs, but the process is relatively homogeneous. Cystic disease, in the true sense of cysts lined by bronchial mucosa, is not present. Clubbing of the smaller bronchi as in adult emphysema may be present. There is no evidence of inflammatory tissue or fibrosis. Small areas of focal atelectasis may accompany the generalized emphysema. In our case, as in those reported by Sloan,[16] the elastic tissue of the alveolar walls was normal.

In 14 of 25 cases reported[5–8,11,14–16] no cause for bronchial obstruction could be demonstrated. In the remaining cases, the cause of the emphysema was thought to be various types of partial bronchial obstruction, acting as a check valve mechanism and allowing inspiratory flow but not expiratory flow of air. These include redundant mucosal flap in 3 cases;[3,8] deficiency of cartilage rings in the bronchus resulting in weakness of the bronchial walls in 4 cases;[7,8,14,16] and compression of the bronchus by an abnormal vein,[14] or an unusual persistent ductus arteriosus[8] in the others. In our case stenosis of the segmental bronchi with normal cartilage and mucosa was present.

DISCUSSION

The etiology of this condition is poorly understood. Congenital alveolar hyperplasia is an attractive possibility. Diffuse lobar hyperplasia due to cystic overgrowth of the bronchi has been noted by Potter[12] in one infant. Potter does not mention alveolar hyperplasia. One wonders if so large a lobe can be produced in the short life of these infants by purely obstructive mechanisms. Potter[12] believes that the fetus "breathes" for many months in utero, and one might therefore postulate that the process is present long before birth. This fails, however, to explain the emphysematous enlargement of the lobes with no demonstrable cause for bronchial obstruction. It is conceivable that in these cases small areas of stenosis were left in the stump of the resected bronchus, and were therefore not available to the pathologist.

Van Epps and Davies[17] suggest that some intrinsic abnormality of the elastic tissue of the lung may be responsible for the emphysema, but were not able to establish or disprove this. Lewis and Potts[11] describe a case discovered in conjunction with a defect in the anterior mediastinal pleura, and express the opinion that the defect may be causative.

Congenital hypertrophic emphysema, as the term of this anomaly, not only embodies our concept of its etiology, but also indicates the nature of the symptoms and pathology. Hypertrophic emphysema in adults[1,2] is differentiated from emphysemas of senility and postural deformity by symptoms and signs very similar to those in the congenital anomaly. The pathology is also quite similar. We also believe that the great size of the affected lobe in congenital hypertrophic emphysema indicates actual overgrowth, as well as simple distention with air. It would seem unwarranted to include the term obstructive in the nomenclature, since no such mechanism has been demonstrated in the majority of cases.

Associated congenital anomalies have been noted only infrequently. Congenital heart disease was present in our case and in cases reported by Sloan[16] and Van Epps and Davies.[17] Pectus excavatum was associated in 2 cases mentioned in the discussion of Sloan's paper. Sloan also reports that in his patients the lung tissue remaining after lobectomy was in some way defective,

since all had some degree of continued respiratory difficulty. Associated mediastinal defect is mentioned above. Other reports available to us did not mention associated abnormalities. This is at variance with the finding of Ferguson and Neuhauser[7] of a high incidence of associated congenital defects in their cases of agenesis of the lung.

TREATMENT

Resection of the emphysematous lobe offers the most promise of permanent cure. The age of the infant presents no contraindication to operation. There is an isolated report[3] of successful management of 2 patients without operation. However, neither of these patients developed any symptoms after an initial episode of respiratory distress of short duration.

Temporization by needle aspiration of the emphysematous lobe, or bronchoscopic aspiration in an attempt to decompress the lobe have been uniformly unsuccessful.[14]

SUMMARY

1. Congenital hypertrophic emphysema is a disease of the early months of life. We believe it is a congenital anomaly, not necessarily based on obstructive lesions.

2. The course may be progressive. Brain damage from hypoxia may occur.

3. History and physical findings are suggestive, and roentgenographic examination establishes the diagnosis.

4. The treatment is surgical, and should be carried out as soon as the diagnosis is made.

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ROENTGENOGRAPHIC DEMONSTRATION OF A DUODENAL ULCER IN THE NEONATAL PERIOD

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THE purpose of this paper is to report the roentgenographic identification of a duodenal ulcer crater in an infant on the first postpartum day. Multiple studies in the past have shown that ulcerative disease is not a rarity in infants and children. It is unusual, however, to demonstrate the crater in infants. This is, to my knowledge, the only reported case in which roentgenographic proof of an ulcer has been elicited in a newborn infant.

REPORT OF A CASE

The patient was the second child born to a twenty-six year old white female. Both mother and father are in good health. The gestation period was close to forty weeks, labor was uneventful.

Following the first feeding the child regurgitated bright red blood. He was taken immediately to the radiologic department where an examination of the upper gastrointestinal tract was made. A soft rubber catheter was passed through the esophagus into the stomach to the level of the gastric cardia. Fifteen cubic centimeters of lipiodol were injected into the stomach. The child was studied in the right lateral and right anterior oblique projections. Spot roentgenograms exposed with a phototiming device resulted in excellent demonstration of an ulcer crater with a surrounding halo of edema in the duodenal bulb.

The patient continued to bleed following the examination; however, the only therapy given was antispasmodic. He bled intermittently for two weeks and at the end of this time a repeat examination again showed an ulcer crater in the same place. After this study no more bleeding occurred. A third upper gastrointestinal series was performed four weeks after the original examination and a perfectly normal duodenum was demonstrated with no evidence of ulcer and no residual deformity.

The infant ate well and showed no particular irritability or evidences of discomfort during this time. Growth and development in the six weeks period were normal. At no time was any clinical abnormality present, other than hematemesis.

A family history showed that the older sibling of the patient had never had any discernible gastrointestinal disease. The mother and father were in good health. The mother had had no prenatal trauma and delivery was routine. No other abnormality in the patient could be detected. The neurologic survey was negative.

DISCUSSION

The fact that infants and children are subject to ulcerative disease of the stomach and duodenum was reported by Cruveilhier in 1829. Since that time postmortem study of infants and children dying from diverse causes indicated that about one per cent of this age group shows ulcerative disease. Berglund[3] gives an incidence of 14 ulcers in 1,323 autopsies for a percentage of 1.07. Benner[2] in 500 routine autopsies in children found 7 ulcers for an incidence of 1.4 per cent. These figures prove that ulcerative disease in infants and children is more prevalent than is generally appreciated. The incidences of perforation and hemorrhage may be no greater than in adults but it is only in the cases with these complications in which the diagnosis is usually made.

The currently discussed case is that of an otherwise normal white male infant. In many cases, however, ulcers of the upper gastrointestinal tract are often associated with specific clinical findings or accompanying abnormalities. These are: (1) circulatory disturbances of the gastrointestinal tract due to: (a) prolonged labor and (b) injury to vasomotor centers from hemorrhage or congenital abnormality; (2) high gastric acidity; (3) trauma—gavage or other instrumentation; (4) sepsis; and (5)

Fig. 1. Lateral roentgenogram showing well demarcated ulcer in duodenal bulb with surrounding halo of edema. This is the initial study at the age of one day.

Fig. 3. Lateral roentgenogram two weeks following original study. The ulcer appears broader but more shallow.

burns and marasmus—this is especially true in older children.

Many cases, including the one discussed, do not fit into any of these categories. Idiopathic ulcerative disease of the newborn may be associated with no definite abnormality in either the mother or child. The disease is by necessity always discovered following a severe complication, usually perforation or hemorrhage. Several case reports have been published citing examples of recovery following operative treatment of such complications.

The disease may be of different etiology than the adult form, but the histologic picture in infants and children is certainly that of an acute peptic ulceration. The ulcers are usually quite shallow and, being acute, are not associated with the scarring deformities characteristic of peptic ulcer in the adu t.

Fig. 2. Phototimed spot roentgenogram in right anterior oblique projection showing ulcer crater and undistorted bulb. Note soft rubber catheter in stomach.

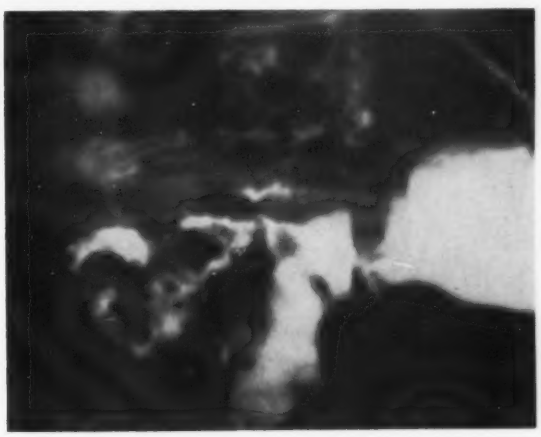

Fig. 4. Roentgenogram four weeks after the first examination. No evidence of ulcer, spasm or scarring.

SUMMARY

1. A patient is reported as being the youngest in whom a duodenal ulcer has been demonstrated roentgenographically.

2. One per cent of children dying from various causes have been shown to have peptic ulceration. With this in mind it is probable that many such ulcerations are

asymptomatic or relatively so and that most remain undiagnosed.

3. Although many ulcers are connected with specific clinical entities or abnormalities, there are many with no clue as to their etiology. This case is one of the latter group.

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VOL. 80, NO. 3

THE SIGNIFICANCE OF SUBDURAL AIR IN PNEUMOENCEPHALOGRAMS IN INFANTS*

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THE significance of subdural air collections which are occasionally observed overlying the cerebral hemispheres in pneumoencephalograms has been the subject of considerable speculation. We have been impressed by the frequency with which such subdural air collections have been associated with subdural fluid collections in the infant under two years of age. That subdural air collections occasionally are associated with such lesions in adults had been demonstrated as early as 1934 by Cramer,[1] who described a case which had subdural air at the time of pneumoencephalography and was found to have a subdural hematoma at operation. Dyke,[2] in 1936, observed air in the subdural space at pneumoencephalography in a case which proved to have a subdural hematoma at operation. Holt and Pearson[7] noted similar findings in 3 cases about the same time. Olsson[19] in one case reported the manner in which a subdural effusion can be outlined by subdural air at pneumoencephalography. More recently, McConnell[15,16] has described cases of proved subdural hematomas which had subdural air collections at the time of pneumoencephalography which he considered pathognomonic of such lesions.

There is, however, no unanimity of opinion in the literature as regards the significance of subdural air in the pneumoencephalogram. Numerous reports concerning the frequency of subdural air are found. Stone and Jones,[22] Lemere and Barnacle,[14] Von Storch and Munro,[23] and Von Storch and Buermann[24] noted subdural collections of air on pneumoencephalography in adults in varying proportions (15 to 39 per cent) in their series of cases, but believed that such collections were of no diagnostic significance.

There are few reports on subdural air collections in children. Ingraham and Matson[10] expressed the opinion that no particular diagnostic importance could be attached to the subdural air which was found in the pneumoencephalograms of several of their series of 98 cases. Elvidge and Jackson,[4] who noted subdural air in some of their 55 cases of subdural hematomas, likewise attributed no significance to this finding. Kinley *et al.*[11] stated that subdural air may be associated with a subdural hematoma, but they did not make mention of its being of any particular diagnostic value.

The importance of the early diagnosis and treatment of subdural effusions in infants, however, was stressed by Ingraham and Matson.[10] It has been found that such lesions in this age group, unless treated early, almost invariably result in generalized debility and neurologic disorders, such as convulsions, evidence of disturbed motor function, and mental retardation. These effusions are much more common than was once suspected, although even today they are sometimes difficult to recognize and are often overlooked. Any means whereby the presence of subdural effusions can be diagnosed will increase the salvage rate of patients affected by these lesions. We reviewed our material at University Hospital with the aim of determining if the presence of subdural air in the pneumoencephalogram can contribute in any way to the diagnosis of subdural effusions.

MATERIAL AND METHODS

All pneumoencephalograms taken in infants under the age of two years during the four year period from July, 1953 to July, 1957 were reviewed. This selection was made because it is in this age group that subdural effusions are most common and

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an appreciable salvage rate may be expected by surgical intervention. A total of 159 pneumoencephalograms were examined. Of these, 66, or 41 per cent, showed the presence of subdural air in some form. The criteria for the diagnosis of subdural air have been well elucidated by others including Stone and Jones,[22] and Von Storch and Buermann,[24] and were followed by us in our study.

Preliminary roentgenograms were taken to be certain that no air, subdural or otherwise, was present prior to pneumoencephalography by the lumbar puncture. In order to demonstrate subdural air collections, erect horizontal beam roentgenograms are necessary and are made routinely. With proper positioning of the patient, such subdural air collections can be demonstrated to move rather freely over the convexities of the cerebral hemispheres. Horizontal beam roentgenograms in the decubitus, brow-up and brow-down positions are helpful and are taken whenever the initial erect roentgenograms disclose the presence of subdural air. Experience shows that subdural air may appear overlying the cerebral hemispheres in certain cases after a lapse of time when it has not been demonstrated on the initial erect roentgenograms. For this reason, we also obtain roentgenograms in the erect position at the end of 24 hours. If the pneumoencephalogram suggests the presence of a subdural effusion, the patient is operated upon, *i.e.*, trephination is done, followed by craniotomy as soon as his clinical condition permits. Preoperative subdural taps are made to reduce the subdural effusion as much as possible prior to surgery.

In reviewing the 66 cases in our series which had subdural air at the time of pneumoencephalography, we found that such subdural air collections had pathognomonic significance as regards subdural effusions only when they had a certain configuration and fulfilled certain criteria. Accordingly, we divided our patients into three groups (Table I). In Group I we placed all cases which demonstrated subdural air overlying the cerebral hemispheres in such a way that the dura was clearly separated from the arachnoid. In the majority of such cases a rather large amount of subdural air was necessary to produce this effect (Case I and II). In some of them we could actually outline the subdural air collections as described by Olsson.[19] With positioning, this air could be demonstrated to move rather freely over most of the cerebral hemispheres. In Group II we placed all cases which showed a subdural air collection overlying the cerebral hemispheres which was noted to be small in amount and did not move freely over the cerebral convexities with proper positioning (Case III). In Group III we placed all cases which showed subdural air merely outlining the tentorium or falx.

TABLE I

Total Cases	Subdural Air Present	Per Cent
159	66	41

Cases with Subdural Air with Definitive Diagnostic Procedures—60

	No. of Cases	Per Cent
Group I	35	58
Group II	17	28
Group III	8	13

In selecting our cases for this study we included only those in which definitive diagnostic procedures were carried out, *i.e.*, trephination and craniotomy, because of the unreliability of subdural taps alone in ruling out a subdural effusion. Six cases had to be excluded for this reason.

RESULTS

Cases which fell into Group I using the above criteria were classified as presumptively positive since of 35 cases in this group, 33 or 94 per cent had a subdural effusion or membrane. In 27 or 80 per cent a subdural membrane was found at craniotomy and was verified by pathologic examination. The results in Group I cases are summarized in Table II.

Table II

Group I	35	Cases
A. Positive for Subdural Effusion	33	94%
1. Subdural membrane	27	80%
2. Subdural effusion only	6	20%
B. Negative for Subdural Effusion or Membrane	2	6%

It is apparent from these results that in the search for subdural effusions, the cases which fell into Group I had the greatest significance. In all of these cases some evidence of ventricular dilatation or subarachnoid sulcus prominence was present. This we believe to be the result of subdural effusion and not the cause of the subdural air shown on pneumoencephalography as assumed by certain investigators. Eighteen or 54 per cent of the cases in this group had bilateral subdural air collections. It appears that bilateral subdural air is strong corroborative evidence of the presence of a subdural effusion.

Cases which fell into the category of Group II had less significance as regards the presence of a subdural effusion. We feel the diagnosis of subdural effusions must be considered only questionable in this group, because out of 17 cases, only 6 were found to have subdural collections on op-

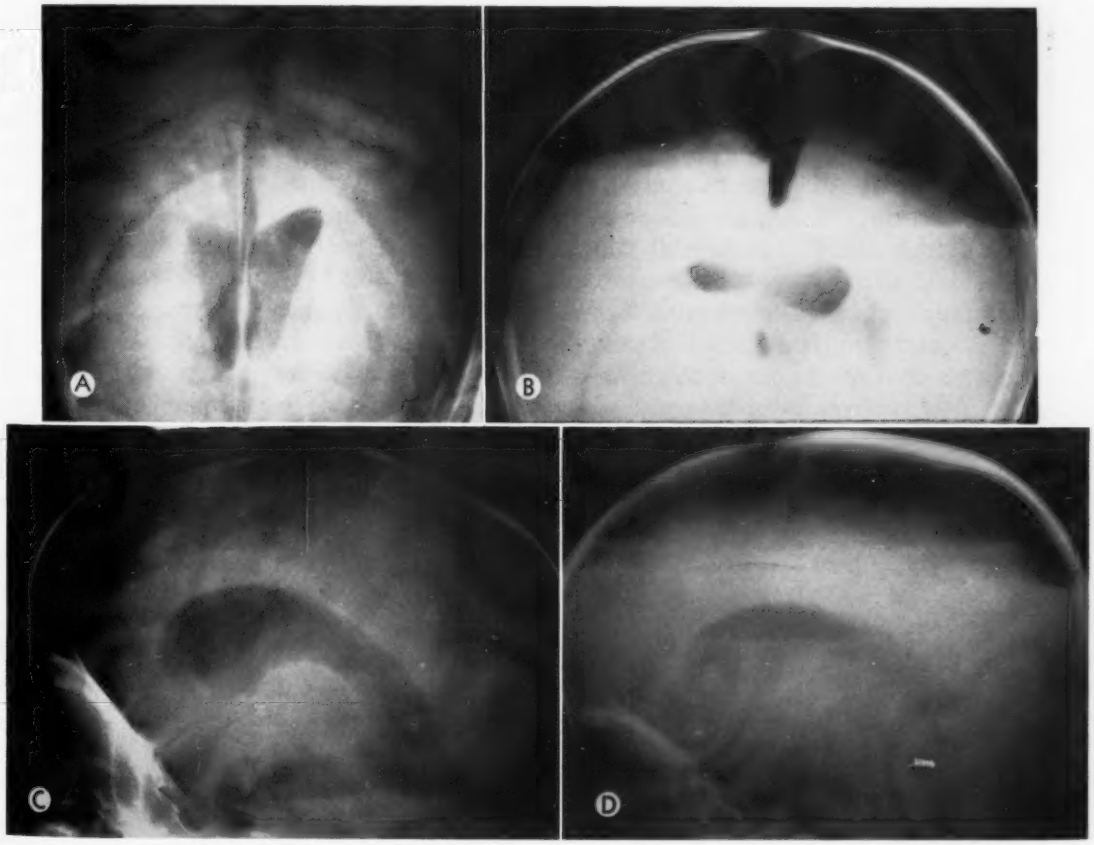

Fig. 1. Case 1. A.K. Nine month old male admitted originally because of pneumococcal meningitis. Patient was retarded mentally and physically with a history of previous trauma. Subdural taps revealed a large amount of xanthochromic fluid. The meningitis was successfully treated with antibiotics after which pneumoencephalography was carried out. (*A*) Supine anteroposterior film showing no subdural air. (*B*) Erect anteroposterior film showing large bilateral collections of subdural air overlying filled ventricular system. (*C*) Supine lateral film showing subdural air over frontal lobes. (*D*) Erect lateral film showing subdural air over convexities. Classified pneumoencephalographically Group I, probable subdural effusion. Trephination revealed bilateral subdural membranes which were removed by craniotomy. Pathologic diagnosis—subdural membrane.

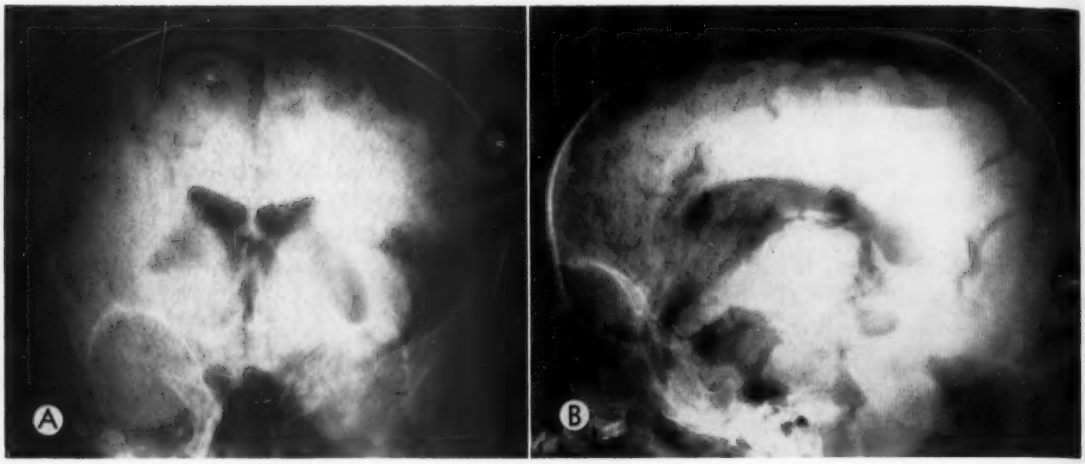

FIG. 2. Case II. D. E. Five month old male admitted because of large head and failure to develop normally. A pneumoencephalogram revealed (*A*) sizable collections of subdural air bilaterally in anteroposterior film; (*B*) subdural air overlying the convexities in lateral erect film. Classified as Group I, probable subdural effusion. Trephination revealed bilateral subdural fluid collections and membranes which were removed at craniotomy. Pathologic examination confirmed the diagnosis of chronic subdural membrane.

eration. A majority of these cases also had so-called cortical atrophy. In only one, however, was the subdural air found bilaterally. Although such unilateral collections of subdural air cannot be considered pathognomonic of a subdural effusion, we do not hesitate to recommend taps and trephination in such patients because we consider negative results in 70 per cent of cases worth the salvage of the remaining 30 per cent.

The remaining cases with subdural air along the falx or under the tentorium alone, *i.e.*, those which fell into Group III, we found of no significance in the search for subdural effusion. One would not, from the distribution of air, expect to find subdural effusions over the convexities. Of the 8

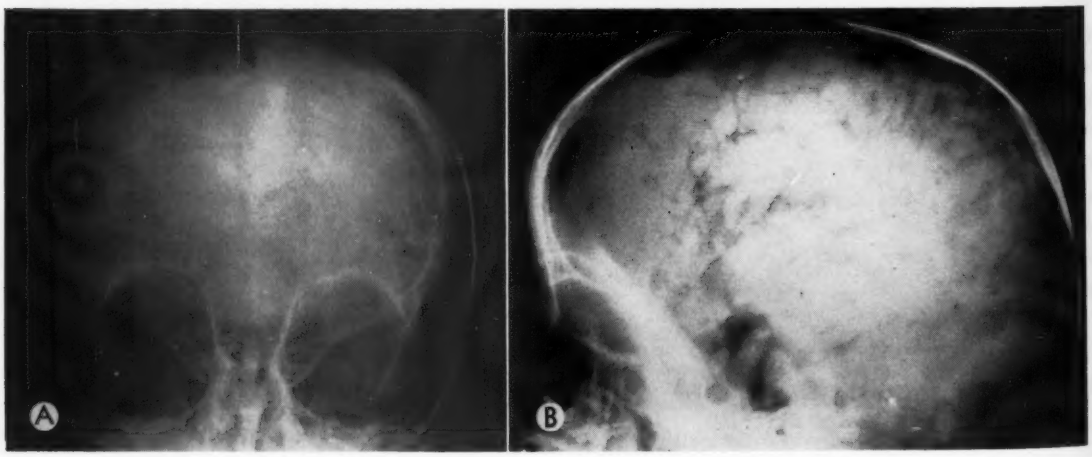

FIG. 3. Case III. E.B. Ten month old male admitted because of mental retardation and failure to gain weight The patient had subdural taps which revealed bilateral xanthochromic fluid collections. A pneumoencephalogram showed (*A*) subdural air collection on the right which was only of moderate amount; (*B*) subdural air overlying the convexities of the cerebral hemispheres. Classified as Group II, possible subdural effusion. Trephination revealed bilateral subdural fluid collections with what appeared to be a right-sided chronic membrane. Craniotomy, however, failed to confirm the membrane.

cases in this group, however, 4 had subdural membranes at operation. Upon investigation it was found that in these 4 false negative cases, the subdural effusion had been reduced in size by repeated taps prior to pneumoencephalography and the brain re-expanded. Subdural air, we noted, cannot be expected, except in an occasional case, to outline an evacuated subdural effusion when the brain has been decompressed and only a membrane remains.

We reviewed the remaining false negatives in this series of 159 pneumoencephalograms, *i.e.*, those cases which had a subdural membrane or effusion on operation, but which showed no subdural air on the pneumoencephalograms. We found that of 15 cases in this group, all but 3 had had repeated taps to evacuate the subdural effusion or membrane—evidence again that subdural air cannot be relied upon to reveal subdural effusions which have been previously reduced in size.

DISCUSSION

The means whereby air reaches the subdural space has been the cause of considerable debate for many years. Pendergrass[20] first suggested that this air reached the cerebral subdural space through an error in technique. He maintained that when the lumbar puncture was performed for removal of fluid and injection of air in pneumoencephalography, a portion of the bevel might remain in the subdural space while the tip of the needle is in the subarachnoid space. Fluid can then be withdrawn, but when air is injected, a portion of it is injected into the subdural space. Although Stone and Jones[22] proved in cadavers that air so injected into the lumbar subdural space can reach the cerebral subdural space, they believed that tears in the subarachnoid membrane over the convexities of the brain more often were the cause of the escape of air into the subdural spaces. Ney[18] demonstrated such a tear in the arachnoid membrane at operation, and many investigators have believed that this is a most common way of entry. Von Storch and Buermann[24] proved rather conclusively, however, that air cannot pass through an intact arachnoid membrane. We have not been able to demonstrate at operation in any of our cases tears in the arachnoid membrane, nor have we been able to find any evidence that such tears existed. We are of the opinion that air which appears over the cerebrum in the subdural space reaches this space following injection of the lumbar subdural space as assumed by Pendergrass.[20] We are now conducting studies aimed at clarifying the role played by the bevel of needle in the entrance of air into the subdural space at the time of lumbar puncture in the hope of proving or disproving this assumption.

Howard[8] has demonstrated that with the removal of a few cubic centimeters of fluid from the lumbar subarachnoid space, a considerable amount of negative pressure is created in the subdural space due to shift of intracranial contents. Many authors have noted the frequent occurrence of subdural air in the presence of so-called cortical atrophy. That such reduction in intracranial content might allow even greater pressures to be developed in the subdural space subsequent to the shift of the intracranial contents has been presumed. It has been suggested that such a shift, by producing tears in the arachnoid membrane, could be the reason for the frequent occurrence of subdural air with cortical atrophy. Smith and Crothers[21] believe that such a sequence of events explains the association of subdural air and cortical atrophy on pneumoencephalography with the subdural hematomas found subsequent to such air studies. They assume that the shift of intracranial contents in such cases producing tears in the bridging pial vessels initiates the subdural hematomas found in about one-third of their cases. That such an hypothetic possibility exists and can take place on occasion cannot be denied.

We do not think, however, that pneumoencephalography was the cause of the sub-

dural effusions found in our series of cases. In Group I, only 6 cases showed the presence of subdural effusion alone without evidence of subdural membrane formation. It may be postulated that in these 6 cases the pneumoencephalography caused the subdural effusion. Each of these cases, however, had clinical symptoms of subdural pathology which antedated the pneumoencephalography and which cleared following removal of the effusions by trephination. This indicates that the subdural pathology was not caused by the pneumoencephalography. In the remaining cases in Group I, subdural membranes which obviously antedated the pneumoencephalography were removed at craniotomy. The presence of the membrane in these cases ruled out pneumoencephalography as a causative factor in the etiology of the subdural pathology. For these reasons, we feel that pneumoencephalography is seldom, if ever, the cause of subdural effusions.

We believe as does McConnell[15,16] that air appears in the cerebral subdural space because the space is occupied by a subdural effusion enabling the air to dissect between the subdural membrane and the arachnoid membrane. This also explains our inability to demonstrate this subdural space when it had been evacuated by taps prior to pneumoencephalography. That the injection of air into the subdural space in the lumbar area is somewhat fortuitous accounts for the fact that all subdural effusions are not outlined by air, and that a certain number of false negatives can be expected in any series of cases. A negative finding on pneumoencephalography is of little importance in evaluating the presence of a subdural effusion.

We have confirmed in one case at operation that the air lies where we expected it to be, *i.e.*, between the inner layer of the subdural membrane and the arachnoid membrane. Dyke[2] had previously suspected, but not confirmed, this finding.

SUMMARY

No conclusions concerning the diagnostic value of subdural air in adult pneumoencephalography can be deduced from this study. In the infant under two years of age, however, subdural air is pathognomonic of a subdural effusion in those cases which fall into Group I according to our criteria, and must be considered of questionable importance, but significant until proved otherwise, in those which fall into Group II.

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ROENTGENOGRAPHIC DEPICTIONS OF CEREBRAL EPENDYMOMAS IN CHILDREN*

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IN 1929,[1] from a study of 8 cerebral ependymomas in Sach's glioma series, it was recorded that in 3 of these supratentorially located tumors, discrete calcific shadows were visualized in the routine skull roentgenograms. It was suggested in that publication that the roentgen translucency of these contrast depositions was not only of localizing significance but also of histologic importance. In an equal span of time, as lapsed for Sach's assemblage of his cases, there has occurred in the author's brain tumor experiences an equal number of such diagnostic delineations. The "calcium shadows" visualized on the roentgenograms of these children's skulls were of such density and of such preciseness as to prompt a preoperative diagnosis of the presence of a cerebral ependymoma. The laboratory interpretations of these "discrete roentgenologic personifications" were subsequently confirmed in the operating theater. Histologic studies in all 3 of the subsequently detailed cases affirmed the preoperative clinical diagnoses.

Some twenty-five years have passed since the initial attention was directed to these rarer roentgenographic characteristics. Perhaps, it is not amiss that interest be again provoked in these rarities: (1) for the benefit of the astute roentgenologic diagnostician; and (2) for the knowledge of his associated neurologic surgeon. The case histories of these 3 ependymal glioma victims are reported in the conviction that the over-all knowledge of both the roentgenologist and the neurologic surgeon, with their combined clinical and laboratory evaluations, is but for the maximal benefit of the proper treatment of such patients.

REPORT OF CASES

CASE 1. W. H. H. (38-504) Ependymoma—right para-central sub-Rholandic. This eleven year old girl was hospitalized December 27, 1938. The neurologic history was of twelve months' duration. Her initial upsets were characterized by attacks of pain, coldness, and numbness of her left hand and arm. As time passed, the "march of attacks" became more extensive. Initially, the seizures occurred three to four times a day and were very transient in duration. Progressively, they became longer and more severe. Six months after onset, general convulsive episodes attended the focal developments. The neurologic examination on December 27, 1938 was quite within normal limits. Roentgenograms of her skull depicted prominent digital markings and a discrete calcium deposit 1 cm. to the right from the midline. The position of this shadow was anatomically just below the estimated position of the right Rholandic vein. The digital markings were attributed to her age, since she had neither cephalalgic complaints nor pathologic optic nerve changes. Following spinal air injection, a depression of the superior part of the body of the right cerebral ventricle and a concaved distortion of the callosal sulcus were visualized (Fig. 1). The density of the calcium shadow was particularly "personified" on these pneumoroentgenograms. On December 30, 1938, a right parietal exposure revealed a 3 by 4 cm. demarcated extracortical tumor. This growth lay directly beneath the right Rholandic vein, and its mesial limitation was a minor concaved displacement of the falx cerebri to the left. It was necessary to divide the Rholandic vein to effect an intact removal of this tumor. This was performed with no gross evidence of physical damage to the mesial aspect of her sub-Rholandic cortex.

Comment. The patient's life since operation has been very gratifying. Her focal seizures have subsided on anticonvulsive medications. She graduated from college with commendatory recognitions. She is the mother of two healthy normal children. Now, nineteen years since her craniotomy, her family and her surgeon are cognizant

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Fig. 1. Case I. Note the depression of the superior part of the body of the right lateral ventricle, also the depression of the right callosal sulcus. The density of the ependymal shadow is intensified by the pneumoencephalographic background.

of the neurosurgical accomplishment. One could presume that she is permanently cured.

Case II. I. P. (44-356) Ependymoma—left parietal-cortical. This ten year old girl was hospitalized April 22, 1944. During the preceding two years, she had suffered from generalized convulsions. These, at one time occurred daily for a period of three months. Anticonvulsive drug therapy was instituted which led to complete control of her seizures. Because of this therapeutic control, a diagnosis of "idiopathic epilepsy" was accepted by her family and her physician. In December of 1943, intracranial pressure symptoms developed. At the time of hospitalization, bilaterally choked disk (5 diopters), a left sixth cranial nerve palsy, a right-sided hypesthesia and paresis were her evident neurologic handicaps. All left kinesthetic functions were in abeyance. Her right-sided reflexes were those of an "upper neurone" character. Roentgenograms of her skull showed increased intracranial pressure, exhibiting inner table digitations and suture separations. In the left mid-parietal region, an irregular deposit of calcium material was noted. The contrast density of this shadow was far greater than that more commonly associated with cerebral glioma (Fig. 2). On April 25, 1944, a left parieto-occipital exposure revealed a new experience for the author. When the osteoplastic flap was reflected, the center of which had been estimated as the site of the roentgenographic translucency, a thinning of the skull at this place was noted to less than 2 mm. and for a diameter of some 1.2 cm. When the dura was reflected, a tumor mass promptly elevated itself for 2.5 cm. above the skull level. This pathologic elevation was the size of a large olive and proved to be a cyst. The fluid aspirated did not coagulate. Once this protrusion was deflated, some 4 stellate cysts, in each instance of less than 0.5 cm. in diameter, were visualized. These gave the appearance of clear grapes. The territorial convolutions were flattened. The tumor mass was circumcised after the cysts had been aspirated. This permitted the surgery to be performed in a pathologic area. The tumor, on delivery, was nodular, of a grayish color, quite firm, and appeared to be totally intact. It measured 4 by 2 cm. and weighed 18.5 gm. Following complete extirpation, a large cystic cavity containing clear fluid seemed to be the occupancy of the pathologic specimen. This cavity was assumed to be the trigone of the left cerebral ventricle. On removal of the clear fluid, no further fluid

Fig. 2. Case II. The density of the tumor shadow residency is well depicted in comparison of the bony falx inclusion. This anteriorly placed contrast occupancy bears no neurologic significance.

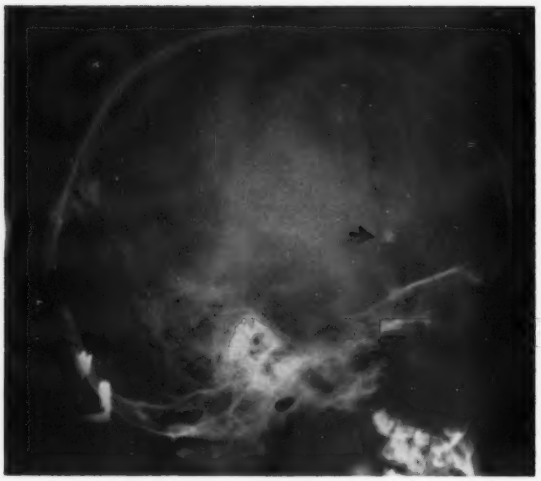

FIG. 3. Case III. The roentgenographic depictions of increased pressure are evident. The discrete, intensely defined contrast shadow, within the substance of the right frontal lobe, prompted the clinical opinion of an ependymal glioma.

was forthcoming. The cavity wall seemed to be normal white matter which was not surgically damaged. An unusual porencephaly was considered. At this point, a lateral bulge of this white brain tissue from the floor of the tumor cavity was noted. Curiosity drove a blunt dissector blade through this bulge. With a lighted retractor, it was evident that the lateral wall of the left ventricle had been opened. For orientation, the left foramen of Munro was demonstrated to the surgical assistants.

Comment. By June 10, 1944, this patient's neurologic handicaps had totally disappeared. As of that date, she had discontinued her anticonvulsive drugs. She has had no seizures in these subsequent thirteen years. She has finished school with a rating of better than average. She is a most attractive young lady and, in accordance with cancer standards, she could be rated as "a cure."

CASE III. W. H. McT. (50-240) Ependymoma—right-frontal. This seven year old male was hospitalized December 10, 1950. For a period of six months, he had suffered early morning headaches. Diplopia was a common complaint of three months' duration. At the time of admission, in addition to choked disks (4 diopters OS, 5 OD), there was a bitemporal limitation of his visual range. Whether this limitation was

FIG. 4. The combined cystogram and ventricular air outlines of Case III attest the value of ventriculography via the anterior horns of these cerebral cavities.[2]

caused by chronically increased intracranial pressure or chiasmal encroachment was a point in question. Routine skull roentgenograms revealed a rounded area of calcification in the right frontal region, measuring 6 to 8 mm. in diameter (Fig. 3). Roentgenographic interpretation was that of a "possible suprasellar cyst." The neurologic surgeon's opinion was that "the density of the opacity was that of an ependymoma." On December 12, 1950, following ventriculography (Fig. 4), a right-frontal cerebral exposure was effected. When the dura had been reflected and hinged parallel with the anterior part of the longitudinal sinus, a frontal cyst was found which was tapped. The fluid was lemon colored, and the protein content was 125 mg. per cent. The cystic cavity was opened, and bulging from a mesial position was a grayish-red tumor. The tumor was nodular, irregular in outline, but anteriorly, superiorly, and mesially, as well as posteriorly, rather sharply demarcated from its cavitation. At the end of a complete intact extirpation, it was definitely established that the right anterior cerebral artery had been clipped just above the level of the division of the anterior communicating vessel.

Its contralateral left twin was normal in physical and functional appearance.

Comment. On January 4, 1951, all intracranial pressure evidences had disappeared. The patient resumed his normal educational and physical activities. He continued to live normally until January, 1952. Early morning headaches and projectile vomiting led to his second hospital entrance on January 26, 1952. He was semistuporous. There was 3 diopters swelling of both optic nerve heads. On January 29, 1952, he was subjected to a second right-frontal craniotomy. At this time, a large liver colored mass was grossly extirpated from the right anterior frontal fossa. All tissues from the pre-Rholandic veins to the middle cerebral artery laterally were removed. No grossly pathologic tissues remained wide beyond the neoplastic resident. Before June of 1952, evidence of tumor recurrence had developed. Death occurred in late 1952 preceded by two months of amblyopic vegetative existence, without cognizant or evident physical suffering.

CONCLUSION

In concluding, the reiteration of the significance of the density of the calcium deposits in ependymomas as compared with other gliomas should be helpful to the alert radiologist. The clinical histories of these 3 intracerebral ependymoma cases approximately characterize the author's surgical experiences in his total of all of his intracranial tumors of the glioma group. The cooperative help from the radiologic laboratory and the clinical study of these rarer cerebral lesions by the neurologic surgeon should permit both specialties to share the mental rewards of a preoperative diagnostic accuracy.

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CALCIFICATION OF THE HYOID, THYROID AND TRACHEAL CARTILAGES IN INFANCY

REPORT OF A CASE

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LARYNGEAL stridor in an infant may be due to many congenital or acquired conditions. The cause of the laryngeal stridor of the patient reported here was in our experience unique. Since this condition is quite rare and this patient has been followed for seven years, we believe that a report of this case is of interest, especially since the diagnosis depends on roentgenographic studies. The only other case in the literature we could find was by Nabarro in 1952.[7]

REPORT OF A CASE

Case No. 176-187. This three month old, white male infant was admitted to the hospital on March 25, 1950 because of severe stridor, which had been present since the time of birth. The breathing difficulty had interfered with proper feeding, resulting in severe dehydration and undernourishment. Since birth he had suffered several attacks of acute respiratory infections.

In the past history, the only outstanding fact was that the mother had had German measles during the second month of gestation. There were two other siblings in the family who were examined and found to be normal.

On physical examination it was found that the infant weighed 7 pounds. The most remarkable feature was the loudness of the stridor, which could be heard at a considerable distance. The degree of undernourishment was apparent, as was the suprasternal and substernal retraction with each respiration.

All of the laboratory data were within normal limits except for elevation of the blood phosphorus, which was 6.56 mg. per 100 cc. of serum. The findings were: Hb, 11 gm. per cent; red blood cell count, 4,400,000; white blood cell count, 11,000; calcium, 10–11 mg. per cent; phosphorus, 6.56 mg. per cent; alkaline phosphatase, 7 Bodansky units; total proteins 6.85 gm. per cent with normal A/G ratio; urine-Sulkowitch test 1 plus.

Direct laryngoscopic examination was reported as negative.

Roentgenographic studies of the chest showed that the heart was of normal size, shape and position. The lung fields showed a mild degree of emphysema. On the lateral roentgenogram the hyoid, thyroid and laryngeal cartilages were well visualized because of calcium deposits in these structures (Fig. 1). A skeletal survey showed no abnormalities of any of the other bones. A barium swallow was done to determine whether any aberrant mediastinal blood vessels were present; none could be demonstrated.

During his first year of life, the patient was admitted to the hospital several other times because of acute respiratory infections which became less frequent as he grew older. Many of these attacks were thought to be due to aspiration pneumonia. He was last seen on January 21, 1957, at which time he was examined to determine whether a general anesthetic could be given for a tonsillectomy.

As compared with his older brothers, the patient is not as well developed both in height and weight; otherwise he appears to be normal and is able to participate in any games or sports indulged in by children of his age.

Studies of the calcified structures of the upper respiratory tract have been made at intervals. The amount of calcium deposit has remained stationary and the new growth of cartilage in the structures has been normal (Fig. 2).

No studies were available to determine whether calcification of these structures was present during the period of gestation. Since the stridor was noticed just after birth, it is very probable that the calcification developed in utero.

The significance of the elevation of the blood phosphorus is not clear. As far as could be determined it produced no clinical symptoms. Efforts to reduce it with low phosphorus intake in the diet did not alter the high blood level.

DISCUSSION

It is not the purpose of this paper to review the literature on the ill-defined and not too well understood entity of chondro-

Fig. 1. Case No. 176–187, at three months of age. Calcification of the hyoid bone, thyroid and tracheal cartilages.

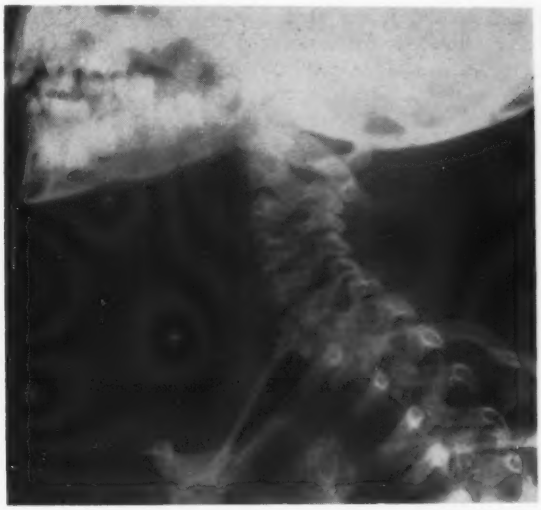

Fig. 2. Same patient as in Figure 1 at five years of age. Calcification of these structures is still visible; however, cartilage growth has occurred since the first examination.

dystrophia calcificans congenita, since numerous authors have reported on the subject.[1–3,5,6,8–11]

Although the case reported here may conceivably be included under chondrodystrophia calcificans congenita, it does not fulfill any of the five criteria set up by Mosekilde,[6] who reviewed the literature on 39 cases and added 3 of his own. He listed the following characteristics of the disease and stated that in most instances two or more of them were present: (1) micromyelia and rhizomelia; (2) additional shortening of one or more extremities; (3) semiflexion and limitation of extension of the larger joints; (4) bilateral cataracts; (5) stippled epiphyses. Calcification of the cartilages of the upper respiratory tract was mentioned only as an incidental finding and only in a very few of the reported cases.

The fact that the mother had German measles in the second month of gestation may have been an important etiologic factor in our case, since it is well known that the fetus suffers developmental impairment while in utero after the mother has had such infection.[4] However, we cannot present any evidence to support this assumption.

CONCLUSION

It is our belief that cases in which only calcification of the cartilages of the upper respiratory tract is found should not be classified under chondrodystrophia calcificans congenita if for no other reason than to avoid confusion. Perhaps we are not dealing with an entity but rather with complications or end results of a disturbed calcium metabolism which we at the present time do not understand. Perhaps the designation used by Nabarro[7] as calcification of the tracheal and laryngeal cartilages in infancy should be used to describe these cases.

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VOL. 80, NO. 3

CHONDRODYSTROPHIA CALCIFICANS CONGENITA*

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CHONDRODYSTROPHIA calcificans congenita is a rare disorder of infancy characterized by multiple discrete punctate areas of calcification in the epiphyses producing a typical roentgenographic appearance. The sites of predilection are the hips, knees, shoulders, and wrists; the vertebrae, pelvis, and rib ends are less commonly involved. The incidence of the condition is estimated as 1 : 500,000 births.[7]

There are associated changes in the long bones of the extremities (particularly in the femora and humeri) consisting of shortening, thickening and bowing of the shafts with cupping, widening and irregularity of the metaphyseal ends.

Various associated abnormalities may be present. These include flexion deformities, clubfoot, congenital dislocation of the hips, monomelic shortening, saddle nose, microcephaly, oxycephaly, dwarfism, mental deficiency, cleft palate, cardiac defect, cataract, and poor resistance to infection.[1,2,4,5,6,10,11,18,19,20]

This entity was first described in 1914 by Conradi[3] who considered it to be chondrodystrophia foetalis of an abortive type. Since then, cases have been reported under a variety of synonyms: chondrodystrophia calcificans congenita,[1,4,8,18] dysplasia epiphysialis punctata,[6] stippled epiphyses,[10,12] chondroangiopathia calcarea seu punctata,[9,19] and epiphyseal dysplasia punctularis.[12]

Death from infection during the first two years of life is common, but the prognosis is not invariably so poor; cases followed to several years of age are reported.[9,12,14,16,18]

In the event of survival, the punctate densities disappear peripherally in the epiphyses; centrally, epiphyses more normal in appearance become calcified. These ultimately ossify with a variable degree of residual, ranging from marked deformity to relative normalcy. The abnormal calcifications usually disappear by the age of three to four years. Some observers believe that the central epiphysis is formed by coalescence of the punctate densities, but this probably does not occur.[15,16,18]

In addition to the congenital asymmetry of extremity length which may be present, there may be residual hypoplasia of bones following epiphyseal ossification. This results in secondary monomelic shortening. Also, bones never demonstrating stippling may subsequently develop definite chondrodystrophic changes.[18]

The dysplasia is fetal in origin, but the etiology remains obscure. Attempts to implicate maternal infections or other prenatal influences have failed. There appears to be a familial tendency as cases in siblings are reported.[7,11,16] Fraser and Scriver's[7] statistical analysis of the literature suggests that the familial distribution is consistent with the hypothesis that the disease shows simple recessive mendelian inheritance. In contrast to earlier literature, they found no significantly higher incidence in females than in males.

Blood chemistry studies are ordinarily within normal limits. An elevation of alkaline phosphatase has been noted by some authors.[1,4] Urinalysis is normal.

Anatomically, there is a disturbance of vascularization of the epiphyseal cartilage and of the cartilaginous anlage of the small bones in the ankle and wrist. This results in an extreme vascularity and mottled mucous degeneration with consequent fragmentation of the hyaline cartilage. These fragments become foci for calcareous cartilaginous deposits with associated punctate ossification.[13]

Two representative cases of chondrodystrophia calcificans congenita are reported:

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REPORT OF CASES

CASE 1. J.S., a colored female, was spontaneously delivered on February 14, 1954. She weighed 8 lbs. 12 oz. at birth. The baby was slow to breathe and there was some cyanosis initially which soon cleared. The appearance of the newborn was striking. She was noted to have an extremely flattened nasal bridge, short neck, and short trunk, and a peculiar curve to the dorsolumbar spine described clinically at that time as "saddleback."

Roentgenographic examination (Fig. 1) revealed areas of discrete punctate calcification in the region of the hyoid, at both ends of the humeri and femora, and at the wrists and ankles. There was stippling of the vertebral bodies throughout the spine. The bony nasal bridge was flattened. The humeral shafts appeared somewhat shortened and slightly bowed when compared to other long bones.

The pregnancy was uneventful. The mother was Rh negative, but the infant's Coombs' test was negative. The family history was noncontributory. Eight siblings are all normal.

The patient has been followed for four years, and although development is slow she has had no significant illnesses. She walks and plays quite well but can only say, "mama" and "dada." She is rather irritable in disposition. There is also evidence of considerable visual

FIG. 1. Case 1. Female, aged one day, showing typical punctate calcification at peripheral joints and spine. Note flattened nasal bridge and "stippled" hyoid.

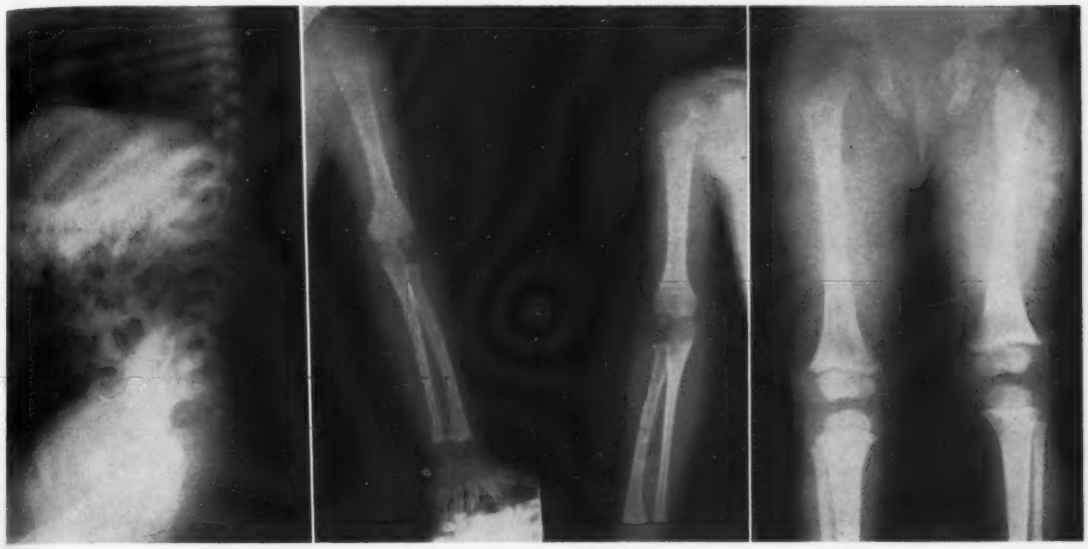

Fig. 2. Case I. Patient at two years of age showing residual deformity of the vertebral bodies. Most peripheral epiphyses appear normal. There is still some "stippling" in the shoulders and wrists.

loss but this is difficult to test with accuracy.

Follow-up studies (Fig. 2) have shown the development of relatively normal appearing epiphyses with peripheral persistence of punctate calcification in some areas. There is no deformity of the extremities, but the carpal and tarsal centers have been retarded in appearance. There is marked residual deformity of the vertebral bodies. The skull is considerably dolichocephalic.

Case II. B.O., a white male, was born on January 5, 1958 following an uneventful thirteen hours labor. Delivery was spontaneous and the baby weighed 6 lbs. 2½ oz. At birth, numerous deformities were apparent, and for this reason the patient was placed in an Isolette, although there was no respiratory difficulty. The infant was noted to have a flattened nasal bridge, disproportionately short arms, and flexion deformities at the elbows, hips, and knees. There was bilateral clubfoot deformity. The hips were dislocated bilaterally (Fig. 3 *D*).

Roentgenographic examination (Fig. 3, *A*, *B* and *C*) revealed areas of discrete punctate calcification at the humeral and femoral ends, the proximal ends of the ulnae, and the proximal ends of the tibiae. There was also stippling of the bodies of the cervical vertebrae, sacrum, acetabula, ischii, right calcaneus, and in both patellar areas. The thoracic and lumbar vertebral bodies were poorly formed with radiolucent bands separating more densely calcified anterior and posterior halves. There were single epiphyseal centers present in each wrist and two in each ankle. The skull, chest and abdomen appeared to be within normal limits.

The pregnancy was uneventful except for a mild terminal hypertension which responded to diet and medical therapy. Both parents were in good health and had no unusual radiation history. Both had negative serologies. There was no maternal family history of congenital deformity. Paternal family history was not available.

The infant did not respond to pin pricks along the spine at birth but responded normally to stimuli on the second and succeeding days. No additional abnormalities have been discovered. The patient is now doing well and is beginning initial orthopedic corrective procedures.

DISCUSSION

The roentgen appearance of chondrodystrophia calcificans congenita is diagnostic, particularly in the newborn. The widespread presence of tiny dot-like calcific densities in and around epiphyseal sites is not simulated by other conditions. The stippling usually occurs earlier than ossification would normally be expected in the epiphyses.

In cretinoid epiphyseal dysgenesis, the epiphyseal fragments are larger, ossified,

FIG. 3. Case 11. Male, aged one day. (*A*) Resting position of infant showing flexion deformities. Punctate calcific densities are widespread in epiphyseal sites. (*B*) Lateral view demonstrating the appearance of the spine. (*C*) Lower extremities forcibly extended. Note dislocation of the hips and shortened femora and humeri. (*D*) Patient at six days of age, showing flattening of the nasal bridge and deformities of the extremities. (Child has been circumcised.)

and conform well to the expected shape of the epiphyses.[17] Epiphyseal development is delayed and responds to thyroid therapy.

Occasionally, in the otherwise normal child, an epiphysis will ossify from multiple centers, but examination of other joints will prevent an erroneous diagnosis of chondrodystrophia calcificans congenita.[5]

The fragmentation and irregularity of epiphyses in the osteochondrodystrophies would not be readily confused, and the classic changes elsewhere (particularly the spine) would direct the observer toward the correct diagnosis.

The epiphyseal mottling and irregularity seen in dysplasia epiphysialis multiplex or the spotting in osteopoikilosis should not be difficult to differentiate from the fine stippling of chondrodystrophia calcificans congenita.

Chondrodystrophia foetalis will show a more widespread involvement of long bones, and epiphyseal fragmentation, if present, will be of a coarser and more limited type.

If the flattened nasal bridge is present in chondrodystrophia calcificans congenita, the facies may resemble that seen in ectodermal dysplasia or congenital syphilis. Roentgenographic examination will immediately exclude these entities.

Treatment is mainly supportive and is directed toward associated abnormalities rather than to the epiphyses *per se*. Early orthopedic care is aimed at prevention and correction of contractures. Extensive procedures are deferred until the patient's mentality can be evaluated.

As regards prognosis, it is interesting to note that the majority of early deaths reported occurred prior to the era of antibiotics and were often due to respiratory and urinary infection. More and more, cases which have been followed well into the first and second decades are appearing in the literature. Of course, in individual cases, the ultimate prognosis depends in large part on the severity of associated abnormalities.

If the disorder is related to simple recessive mendelian inheritance, then siblings of affected children have a one in four chance of similar deformity.

SUMMARY

Two cases of chondrodystrophia calcificans congenita are reported. Review of these and other cases previously described permits a general appraisal of this rare disorder as to diagnosis, natural history, and prognosis. The roentgen appearance is diagnostic. Therapy is primarily supportive in nature. Prognosis is closely related to the degree of involvement and to the severity of other anomalies or abnormalities frequently associated with this condition.

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The authors wish to thank Dr. David M. Gould, Chairman and Head, Department of Radiology, University of Arkansas Medical Center, for permission to publish Case 1, which was initially studied at the University of Arkansas Medical Center.

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Vol. 80, No. 3

ACHONDROPLASIA OF PELVIS AND LUMBO-SACRAL SPINE*

SOME ROENTGENOGRAPHIC FEATURES

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CUSTOMARILY the roentgenographic diagnosis of achondroplasia has rested on changes in long bones in the extremities. The findings in flat and short bones of the pelvis and spine have generally been ignored; in fact, they have never been described adequately. It is our purpose in this report to present detailed description of pelvic and spinal lesions with an evaluation of their usefulness in roentgenographic identification of the disease. Roentgenographic differentiation of achondroplasia from such diseases as late rickets, metaphyseal dysostosis (hypophosphatasia), the Morquio-Brailsford disease, gargoylism and dyschondroplasia cannot always be made satisfactorily from the findings in the long bones.

Primary causal mechanisms in achondroplasia are slowed cartilaginous growth and irregular endochondral bone formation in all bones of cartilaginous origin—in the pelvis, spine, shoulder girdle and skull, as well as in the extremities. Peripheral growth in flat and short bones is retarded in exactly the same way as terminal longitudinal growth in long bones, although the extent and velocity of this peripheral growth is usually not so great.

Typical external disproportions and malformations of achondroplastic children are seen in Figures 1 and 2. The thorax is flat and short although the shoulders are wide, owing to scapular hypertelorism.[1] Lordosis is pronounced at the lumbosacral junction which causes significant loss in length of the achondroplast. The abdomen is also shallow ventrodorsally, albeit protuberant in its lower levels. The pelvic, and to some degree, spinal bones are more deeply buried in soft tissues and, therefore, their dwarfism and deformities are more difficult to appreciate by external inspection. In roentgenograms, however, these pelvic and spinal changes are clearly visible in a highly diagnostic pattern.

All parts of the bony pelvis are smaller in achondroplasts at all ages (Fig. 3, 4, 5 and 6). Pelvic diameters, however, are shortened more in length than in breadth. Iliums are much more dwarfed than ischiums and pubic bones. Loss of length in the iliums contributes significantly to the total loss in stature. Breadth of the pelvis is reduced some by transverse narrowing of the sacrum, which articulates low on the iliums, so that the fifth and part of the fourth lumbar vertebras often lie below the iliac crests. The fifth lumbar segment is said to be frequently sacralized. Also, it is claimed that as age advances, the entire sacrum turns on a transverse axis through the second sacral segment, with shift upward and backward of the coccyx and lower sacral segments, and shift forward and downward of the first sacral segment and its promontory. It is the forward impingement of the sacral promontory which flattens the pelvis and compresses the pregnant uterus to cause dystocia in achondroplasts.

Of all pelvic bones, the iliums are reduced the most. In the normal bone, the greater sciatic notch is long and shallow, and the entire segment below the posteroinferior iliac spine is elongated and tapers caudad to a narrow base at the Y cartilage. In the achondroplastic ilium, the greater sciatic notch is flattened to a narrow and relatively deep cleft; the lower tapered segment fails to develop and the base of the ilium is almost as wide as its top. The entire iliac ossification center has four roughly

* From Departments of Pediatrics and Radiology, College of Physicians and Surgeons, Columbia University and Babies Hospital. Presented at the Fifty-eighth Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 1–4, 1957.

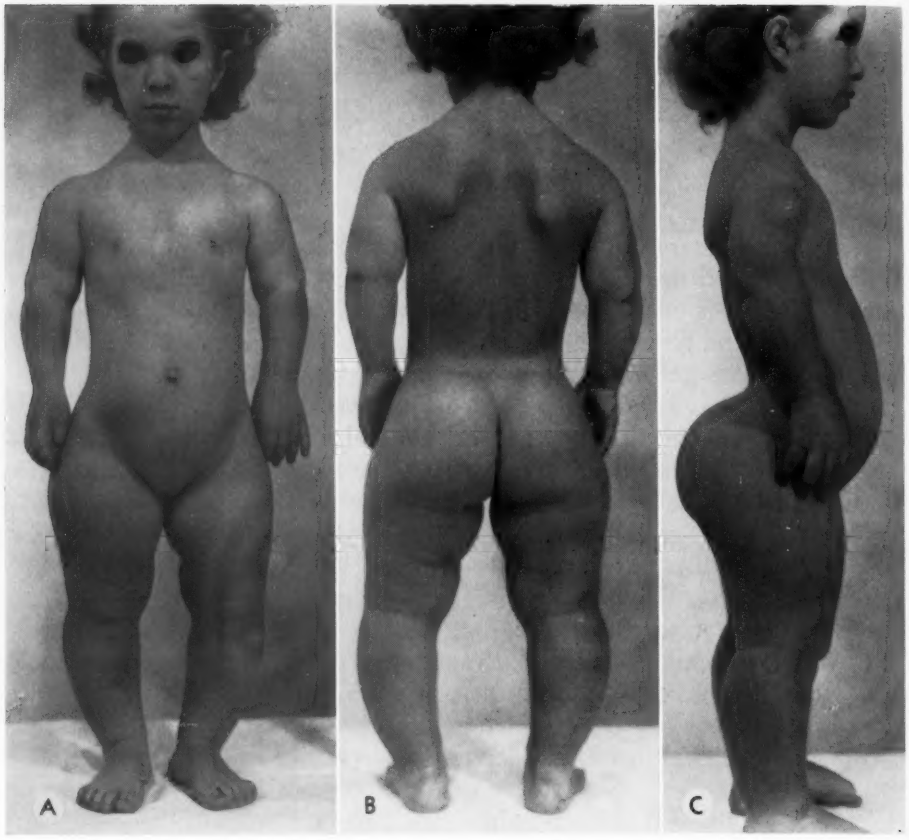


FIG. 1. External disproportions in an achondroplastic girl, eleven years of age. (*A*) Frontal; (*B*) dorsal; and (*C*) lateral aspects. Total stature is reduced and arms and legs are relatively shorter than trunk and skull. In frontal projections the wide shoulders give a false appearance of a large sthenic thorax. Actually the thorax is small in all diameters with marked ventrodorsal flattening. Abdomen is also flat although protuberant in its lower levels. Relatively, the hands and feet are large. Lumbosacral lordosis is pronounced; the buttocks are heavy and bulge dorsad on each side of a deep gluteal cleft. Scapulae are widely separated (scapular hypertelorism) and are winged.

equal, flattened sides with irregular edges, above and below. The normal ilium has the general shape of a short paddle with a wide flaring blade above and a narrow tapering handle below; in achondroplasia the handle is missing and the blade is squared. The flat lower bony edge above the acetabulum is greatly elongated and does not have the normal tilt cephalad, laterally; as a result, the acetabular angles are reduced to near zero and in some severe cases, the lower edge is tilted caudad, laterally, which reverses the acetabular angles to negative values. It is possible that in roentgenographic examination, malrotation and tilting of individual bones play some part in deforming their images, as well as the actual structural changes in the bones themselves; however, this foreshortening of the images due to tilt is probably a minor causal factor in formation of the total roentgenographic image of the achondroplastic pelvis.

Cartilage is excessive in the achondroplastic pelvis which is indicated roentgenographically by the increased size of cartilage spaces and reduced size of the ossification centers. This excess is best seen at the Y cartilages and is most pronounced in newborns; but it gradually lessens with advancing age and disappears completely during the later years of childhood. The

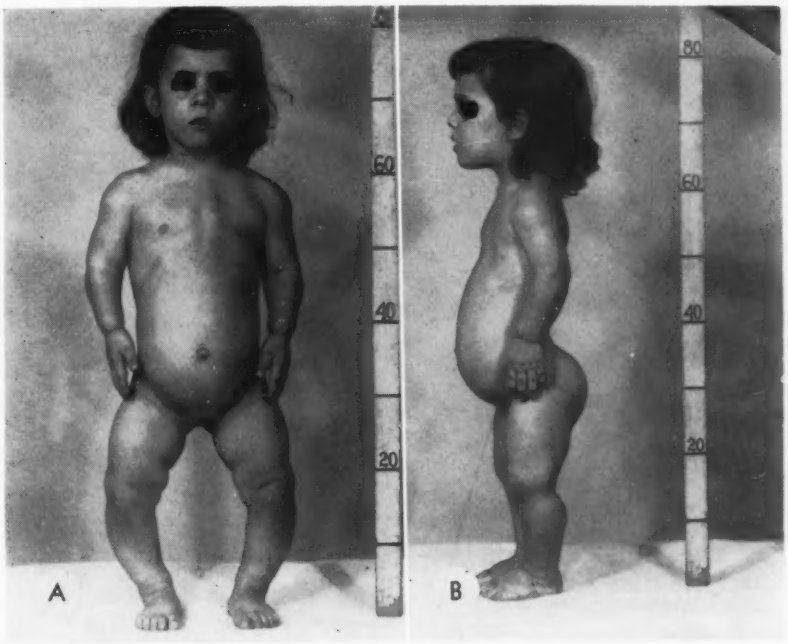


FIG. 2. Achondroplastic girl six years of age. (*A*) Frontal and (*B*) lateral aspects. The thorax appears to be large and full in frontal view owing to the widely spaced shoulders; in lateral view it is shown to be very flat and short. Pronounced lumbosacral lordosis and conspicuous buttocks are seen in lateral view.

ischiopubic synchondroses may be an exception to this rule; we have seen them disappear early. The secondary epiphyseal ossification centers in the femurs appear late and are too small, well into late childhood.

In the spine, as in the remainder of the skeleton, all ossification centers in cartilage are too small and there is an excess of carti-

FIG. 3. Comparison of normal pelvis (*A*) with achondroplastic pelvis (*B*) at five years of age. In *B*, excess of cartilage is evident at the Y-cartilages, which are thicker. Iliac ossification centers are smaller and tend to be square. Practically all of each ilium below the posteroinferior spines is missing; the greater sciatic notches are reduced to narrow clefts. Lower edge of each ilium is elongated and flattened and roughened. Acetabular angles are reduced to near zero. Sacrum is narrow and articulates low on the iliums. Ischiopubic synchondroses are closed in the achondroplast, but still widely open in the normal.

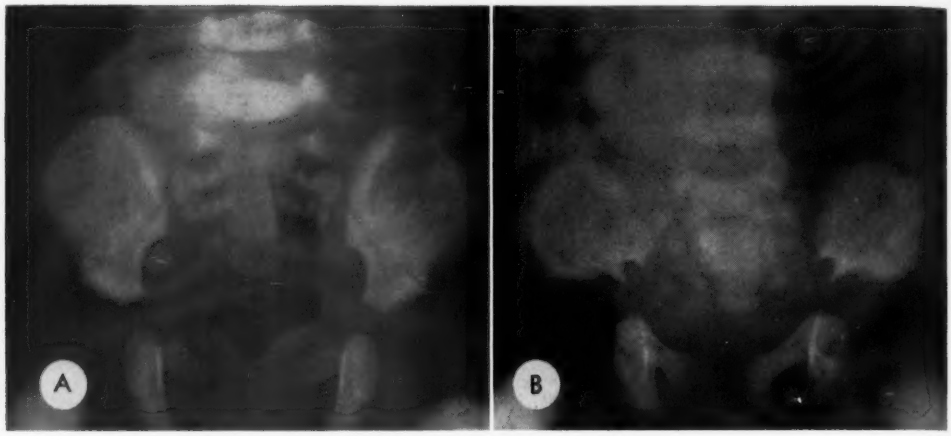


FIG. 4. Comparison of normal pelvis (*A*) with achondroplastic pelvis (*B*) in newborns. Findings are similar to those in Figure 3. Flattening of acetabular angles is more conspicuous at this age; in the achondroplast these angles approach zero while they equal 28 degrees and 24 degrees in the normal pelvis.

lage (Fig. 7, 8, 9 and 10). There is an absolute and relative increase in the cartilage of young achondroplastic spines. For example, at twelve months of age, the ratio of height of a single normal vertebral body to thickness of each of its contiguous normal intervertebral disks is about 3 to 1, whereas the ratio of height of a single achondroplastic vertebral body to thickness of each of its contiguous intervertebral disks is about 1 to 1. In newly born and prenatal achondroplastic spines, the intervertebral spaces are considerably thicker than their contiguous vertebral bodies. Dorsal edges of vertebral bodies are straight or slightly convex in normals, and concave in achondroplasts; these dorsal concavities are greatest at the lumbar levels. Undergrowth of pedicles is a conspicuous feature of the achondroplastic vertebras; they are shortened to approximately one-half their normal lengths. Pediculate length is a good

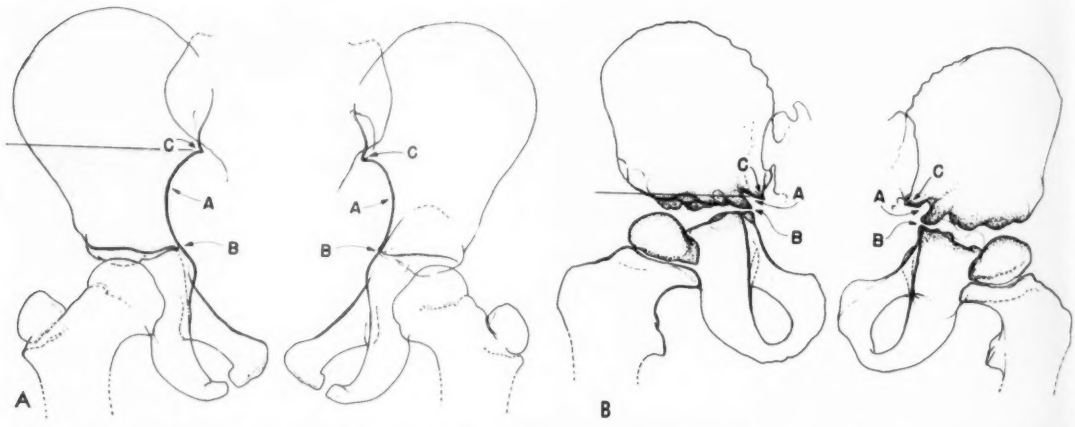


FIG. 5. Comparison of normal (*A*) and achondroplastic pelves (*B*) at five years of age, in tracings of the roentgenograms from Figure 3. On the right side, segments of ilium below the posteroinferior iliac spine are marked in cross line in the normal (*A*) and stippled in the achondroplast (*B*). Letters A and A′ mark the greater sciatic notches in normal and achondroplast respectively; B and B′, the Y-cartilages; C and C′, the posteroinferior iliac spines. In the achondroplast practically all of the iliums below these spines is missing and the greater sciatic notches are reduced to tiny, but deep clefts. Iliums are squared with elongated flat lower edges.

measure of spinal canal depth at the same level; the achondroplastic spinal canal appears to be flattened ventrodorsally by about one-half.

Regional undergrowth of the ventral ends of some lumbar vertebral bodies appears to be responsible for their wedging ventrad and the pinching of their ventral ends into rounded bullet-nose deformities (Fig. 8 and 10). In our achondroplastic patients, these deformities have been found only after the first year of life; similar deformities have been present in cretins and gargoyles during the first months of life. Severe local hypoplasia of a lumbar body may lead to painful sharply-angled kyphosis during later childhood (Fig. 11).

Marked transverse smallness of the lower lumbar bodies is a most consistent and diagnostic finding. This progressive terminal lumbar stenosis is especially conspicuous in achondroplasts, because normal spines widen progressively at these same levels. In the normal lumbar spine, the fifth lumbar body is the widest, by far; in the achondroplastic lumbar spine, the fifth lumbar body is the narrowest by far. In the normal, the ratio of width of the first lumbar to width of fifth lumbar body is about 0.70; in the achondroplast, the same ratio is about 1.2. The fourth and third lumbar

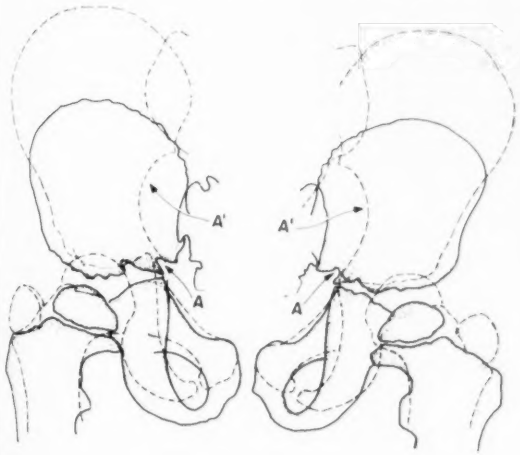


FIG. 6. Comparison of normal (broken line) and achondroplastic pelves (continuous line) by superimposition; tracings of roentgenograms from Figure 3. Approximately two-fifths of iliac length is lost due to absence of the lower tapering segments below the posteroinferior iliac spines. The ischial and pubic bones are relatively little affected.

FIG. 7. Comparison of normal lumbar spine (*A* and *C*) with achondroplastic spine (*B* and *D*) at twelve months of age. Excessive cartilage in the achondroplastic spine is shown by the greater depth of its intervertebral spaces. Bodies of normal lumbar spine widen progressively downward with wide flare in its lower two segments; bodies of achondroplastic spine taper progressively downward with increased stenosis in its lower two segments. In *D*, the pedicles are shortened and dorsal edges of the bodies are all concave.

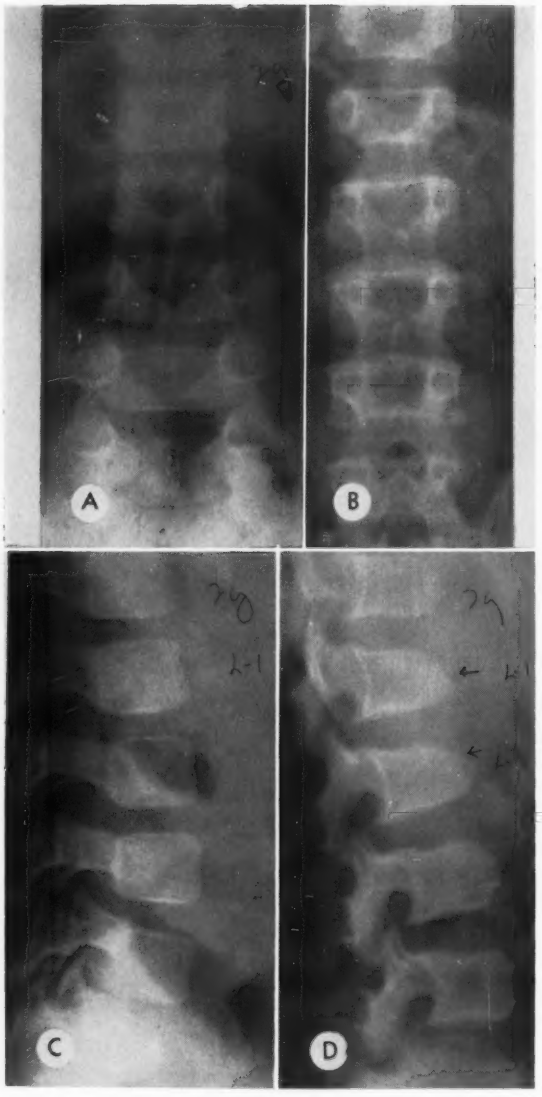


FIG. 8. Comparison of normal lumbar spine (*A* and *C*) with achondroplastic lumbar spine (*B* and *D*) in frontal and lateral projections at twenty-four months of age. Findings are similar to those in Figure 7 with the addition of smallness and pinching of the ventral ends of the first and second lumbar bodies into rounded bullet-nosed deformities.

bodies present the same transverse stenosis, but in less degree.

The spinal canal in the lumbar region is narrowed transversely in the same fashion, and at the same levels (Fig. 10, 12 and 13). Normally, the spinal canal widens progressively in the lower lumbar levels,[5] but in achondroplasia at the same levels the spinal canal tapers progressively downward. We have shown that the lumbar spinal canal in achondroplasts is flattened, both anteroposteriorly and from side to side (Fig. 10). Vogl and Osborne[6] have pointed out the smallness of achondroplastic spinal canals, and the virtual obliteration of their subarachnoid and epidural spaces. In adult achondroplasts, dorsolumbar kyphosis and hypertrophic osteoarthritis may precipitate early neurologic disturbances owing to smallness of the

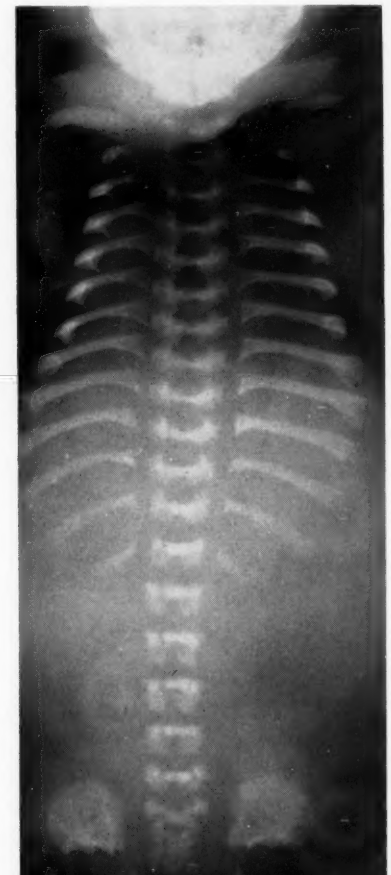
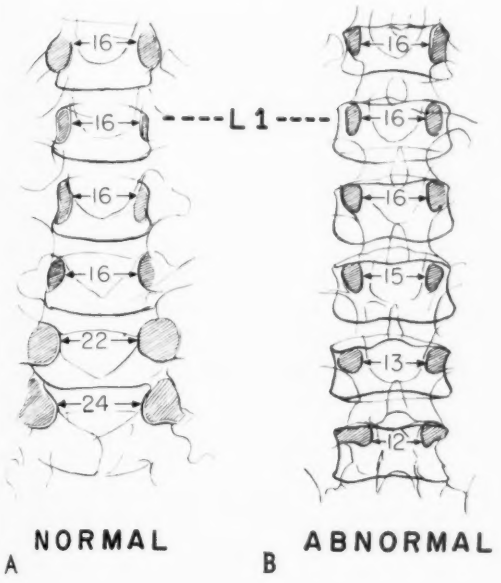


FIG. 9. Spine of an achondroplastic stillborn fetus of uncertain age. The taper caudad in the width of the lumbar bodies is already well developed as are classic changes in the pelvis. The intervertebral spaces are several times thicker than their contiguous vertebral bodies.



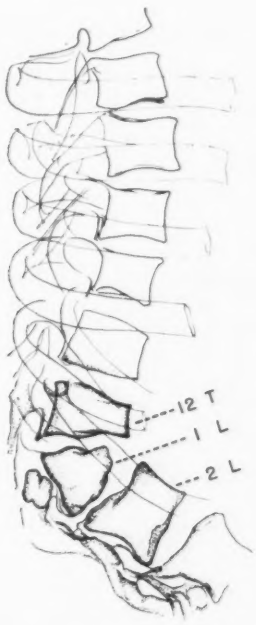


FIG. 11. Thoracolumbar kyphosis due to hypoplasia of first lumbar body in an achondroplastic girl eleven years of age; tracing of original roentgenogram, a lateral projection of thoracolumbar spine. The first lumbar body is small, wedged ventrad and displaced dorsad. Narrowing of contiguous intervertebral spaces and indentation in contiguous edges of vertebral bodies raise the question of multiple herniations of nuclei pulposi.

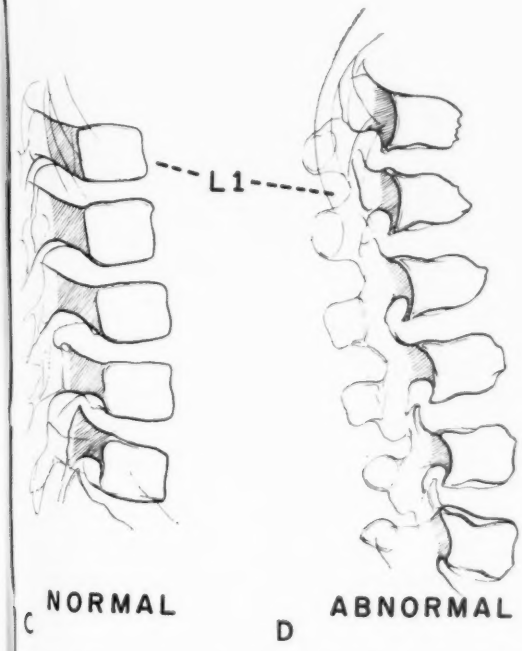


FIG. 10. Comparison of normal (*A* and *C*) spine with achondroplastic spine (*B* and *D*) at twenty-four months of age by tracings from films of Figure 8. Pedicles are emphasized by heavier shading. A horizontal arrow measures the interpediculate space of each vertebral body in millimeters, according to the method of Elsberg and Dyke.[3] All of the features in Figure 8 are brought out semischematically. In the normal, interpediculate spaces increase in length from above downward 50 per cent, from 16 mm. in the first lumbar to 24 mm. in the fifth lumbar. In the achondroplast, interpediculate spaces decrease in length from above downward 25 per cent, from 16 mm. in the first lumbar to 12 mm. in the fifth lumbar. In lateral projection (*D*), pedicles are shortened ventrodorsally and dorsal edges of bodies are concave.

spinal canal. Schreiber and Rosenthal[4] reported 2 cases of herniation of intervertebral disks with partial paralyses and pains in the legs of achondroplasts. Both of these patients were relieved by surgical decompression of the spinal canal.

SUMMARY

Roentgenographic findings in achondroplastic pelves and spines are described and compared with normal findings.

In the pelvis, the iliums are the most conspicuously affected bones. Shortening

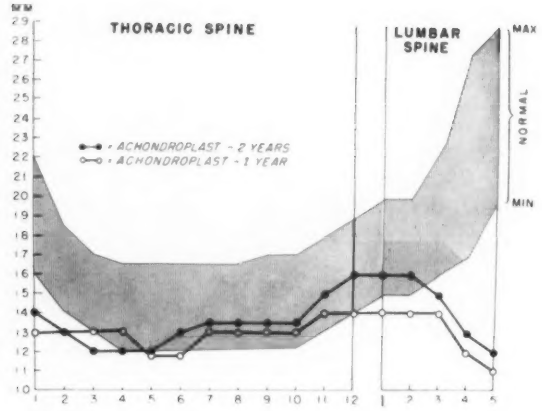


FIG. 12. Quantitative comparison of size of interpediculate spaces in normal and achondroplastic spines according to the normal standards of Simril and Thurston[5] for persons two to twenty-four months of age. Achondroplastic values are small at all levels in the spine. In the lower two lumbar segments where interpediculate spaces increase sharply in normals, they diminish sharply in the achondroplasts; the fifth lumbar interpediculate space is approximately 70 per cent of the first interpediculate space.

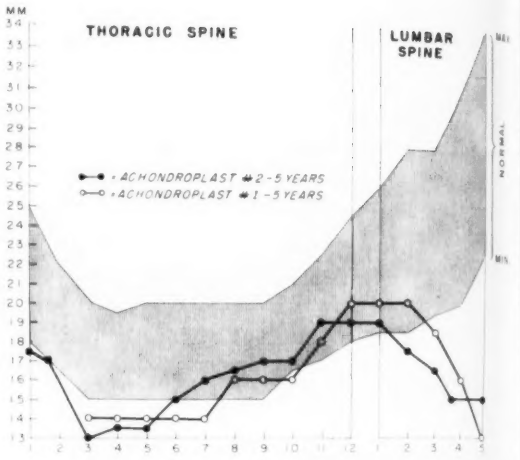


FIG. 13. Quantitative comparison of size of interpediculate spaces in normal and achondroplastic spines at five years of age according to the normal standards of Simril and Thurston[5] for children older than two years of age. The findings are similar to those for the younger achondroplasts of Figure 12, but the terminal stenosis of the spinal canal is relatively greater; the fifth lumbar interpediculate space is approximately 60 per cent of the first interpediculate space.

of the ilium is greatest in the caudal segment of the wing and its body, all below the posteroinferior iliac spine. The greater sciatic notches are reduced to narrow deep clefts. Acetabular angles are either obliterated or greatly reduced.

In the spine, fourth and fifth lumbar segments are the most affected. Width of these bodies is greatly diminished and the dorsal edges of their bodies are concave. At the same levels, the spinal canal is flattened transversely; at all levels the spinal canal is flattened anteroposteriorly owing to shortness of pedicles. The sacrum is narrow transversely at all levels and articulates low on the iliac wings.

CONCLUSION

Slowed and irregular growth of pelvic and spinal bones produces some of the most diagnostic changes in the entire achondroplastic skeleton; often they are more conclusive than changes in the long bones of the extremities.

Pelvic and spinal changes readily differentiate achondroplasia from rachitic dwarfism, gargoylism, metaphyseal dysostosis and dyschondroplasia. Pelvic and spinal changes are similar in achondroplasia and chondroectodermal dysplasia (Ellis-van Creveld disease). The iliac changes in Morquio's disease and achondroplasia may be identical; however, the femoral heads and necks are ossified late in Morquio's disease.

In all achondroplasts, stenosis of the spinal canal produces a disproportion in which the canal is too small for its contents —the spinal cord, membranes, fluid spaces, and blood vessels. All achondroplasts should be studied carefully for the appearance of neurologic deficits; and in appropriate circumstances decompression laminectomy should be done early, before irreversible changes develop in the spinal cord.

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PELVIC BONES IN INFANTILE MONGOLOIDISM*

ROENTGENOGRAPHIC FEATURES

By JOHN CAFFEY, M.D., *and* STEVEN ROSS, M.D.†
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DIAGNOSTIC changes in the pelvic bones of mongoloid infants were first described during 1956.[1] In this preliminary report on 18 mongoloids who varied in age from two to ninety days, the pelves of mongoloids were compared with the standard for normal pelves of the same age, established in another investigation.[2] There were two cardinal diagnostic features in the pelves of these very young mongoloid infants: (1) flattening of the underedges of the iliums and (2) widening of the iliac wings and bodies. The former was measured quantitatively as the acetabular angles (Fig. 1) and the latter as the iliac angles (Fig. 2). In comparison with the values for normal infants, these measurements were greatly reduced in the mongoloids. In addition, an iliac index was designed which included both features—the sum of both acetabular and both iliac angles divided by 2—and this also was significantly smaller than the iliac indices for normal infants. Substantial variations were found in both of these features, both in normal and mongoloid infants, but with surprisingly little overlap of the normal distribution and the mongoloid distribution. Scattergrams showed that the mongoloid overlap of the normal was confined to the smaller half of the normal distribution with the exception of one newly born mongoloid girl, who had values above the normal means, but who, nevertheless, was a pronounced mongoloid clinically. The scores for 29 of the 36 mongoloid hips lay at or beyond the lower limits of the normal two standard deviation (SD) zones; the probability that the low scores in mongoloids represented mere chance selection in the normal population approached zero.

In several older infantile mongoloids, not included in the statistical report, we

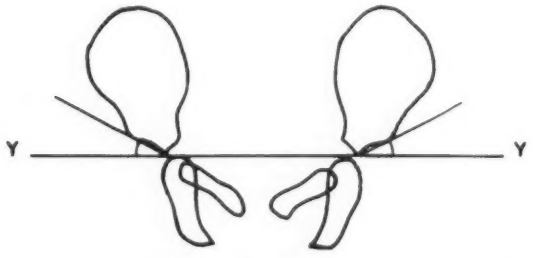

FIG. 1. Schematic drawing for measurement of the acetabular angles according to the method of Hilgenreiner. The horizontal Y-Y line is drawn through the two "Y" cartilages. A secondary line is then drawn on each side which connects the two ends of the caudal edge of the ilium. The lateral angles, between the Y-Y line and these secondary lines, which measure the tilt of the lower iliac edge are called the acetabular angles. There is an inverse ratio between the flattening of the lower iliac edge and the size of the acetabular angle.

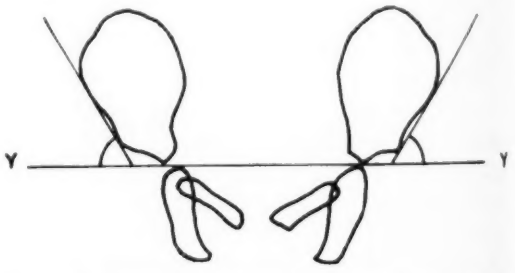

FIG. 2. Schematic drawing for measurement of the iliac angles according to the method of Ross. The Y-Y line is drawn through the "Y" cartilages and then a secondary line is drawn on each side which connects the lateral end of the lower edge of the ilium with the outermost point on the lateral edges of the ilium. The lateral angles, between the secondary lines and the Y-Y line, which measure the width and especially the flare lateral of the iliac wings are called the iliac angles. There is an inverse ratio between width and flare of the iliac wing and the size of the iliac angle.

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TABLE I

ACETABULAR ANGLE, ILIAC ANGLE AND ILIAC INDEX FOR 48 INFANTS WITH MONGOLOIDISM DURING THE FIRST YEAR OF LIFE

Case No. Sex Age	Acetabular Angle in Degrees	Iliac Angle	Iliac Index	Case No. Sex Age	Acetabular Angle in Degrees	Iliac Angle	Iliac Index
1—M—Nb.	12	36	48	25—M—2½ mo.	13	42	55
2—M—Nb.	16	39	55	26—M—3 mo.	10	44	54
3—M—Nb.	13	42	55	27—M—3 mo.	7	34	41
4—M—Nb.	9	40	49	28—M—3 mo.	19	40	59
5—M—Nb.	17	40	57	29—F—3 mo.	11	26	37
6—M—Nb.	18	52	70	30—M—3½ mo.	14	49	63
7—M—Nb.	21	41	62	31—M—4 mo.	7	42	49
8—F—Nb.	15	53	67	32—M—4 mo.	13	32	44
9—F—Nb.	18	39	57	33—F—4 mo.	8	34	42
10—F—Nb.	24	40	64	34—M—4½ mo.	17	50	67
11—F—Nb.	29	58	87	35—F—4½ mo.	10	43	53
12—M—4 da.	9	41	50	36—M—5 mo.	10	34	44
13—F—6 da.	18	57	75	37—M—6½ mo.	17	43	60
14—F—7 da.	20	35	55	38—M—7 mo.	6	28	34
15—M—10 da.	12	50	62	39—F—7 mo.	18	41	59
16—M—12 da.	13	45	58	40—M—8 mo.	9	44	53
17—M—3 wk.	13	52	64	41—M—8 mo.	19	45	63
18—M—4 wk.	13	43	56	42—M—8½ mo.	10	40	50
19—M—6 wk.	14	37	50	43—F—9 mo.	7	26	33
20—M—6 wk.	19	45	64	44—F—9 mo.	11	35	46
21—M—10 wk.	15	35	50	45—F—10 mo.	6	36	42
22—M—10 wk.	13	43	56	46—M—11 mo.	9	47	56
23—F—10 wk.	19	38	57	47—F—12 mo.	7	45	52
24—F—2½ mo.	12	47	59	48—F—12 mo.	9	43	52

The values given for the acetabular angle and the iliac angle represent the mean values for the two sides (right and left) for these angles, rounded up to the nearest integer. Since in some patients both of these values were rounded up, in these cases the iliac index shown is one unit smaller than the sum of the two angles given.

M = male F = female Nb. = newborn da. = day wk. = week mo. = month

observed frequent bilateral symmetric smallness of the ischial rami, both superior and inferior. In the first 18 mongoloids studied, the pelvic changes appeared to be more marked in boys.

We have now examined 48 mongoloid infants, who varied in age from two days to twelve months, in exactly the same way; and the scores for their measurements appear in Table I. The characteristic roentgenographic features of mongoloid pelves, in their different variations and patterns, are depicted in Figures 3, 4, 5, 6 and 7. Essential statistical analyses of the data in Table I are found in Table II. The measures of central tendency—the means—are substantially smaller in mongoloids in all categories and at all ages. Cases were divided into two groups: the "younger" mongoloids and "younger" normals represent infants younger than three months, and the "older" mongoloids and "older" normals represent infants from three months to twelve months of age. The actual mean age for this younger group of mongoloids was twenty days; and for the older group of mongoloids it was one hundred and ninety-five days.

The degrees of variation in mongoloids and normals is indicated in the standard deviations (SD), the two SD ranges and the actual ranges in Table II. The scatter of individual mongoloid scores and the overlaps of the mongoloids in the normal frequency distribution are shown in Figures 8, 9 and 10. There is a conspicuous small-

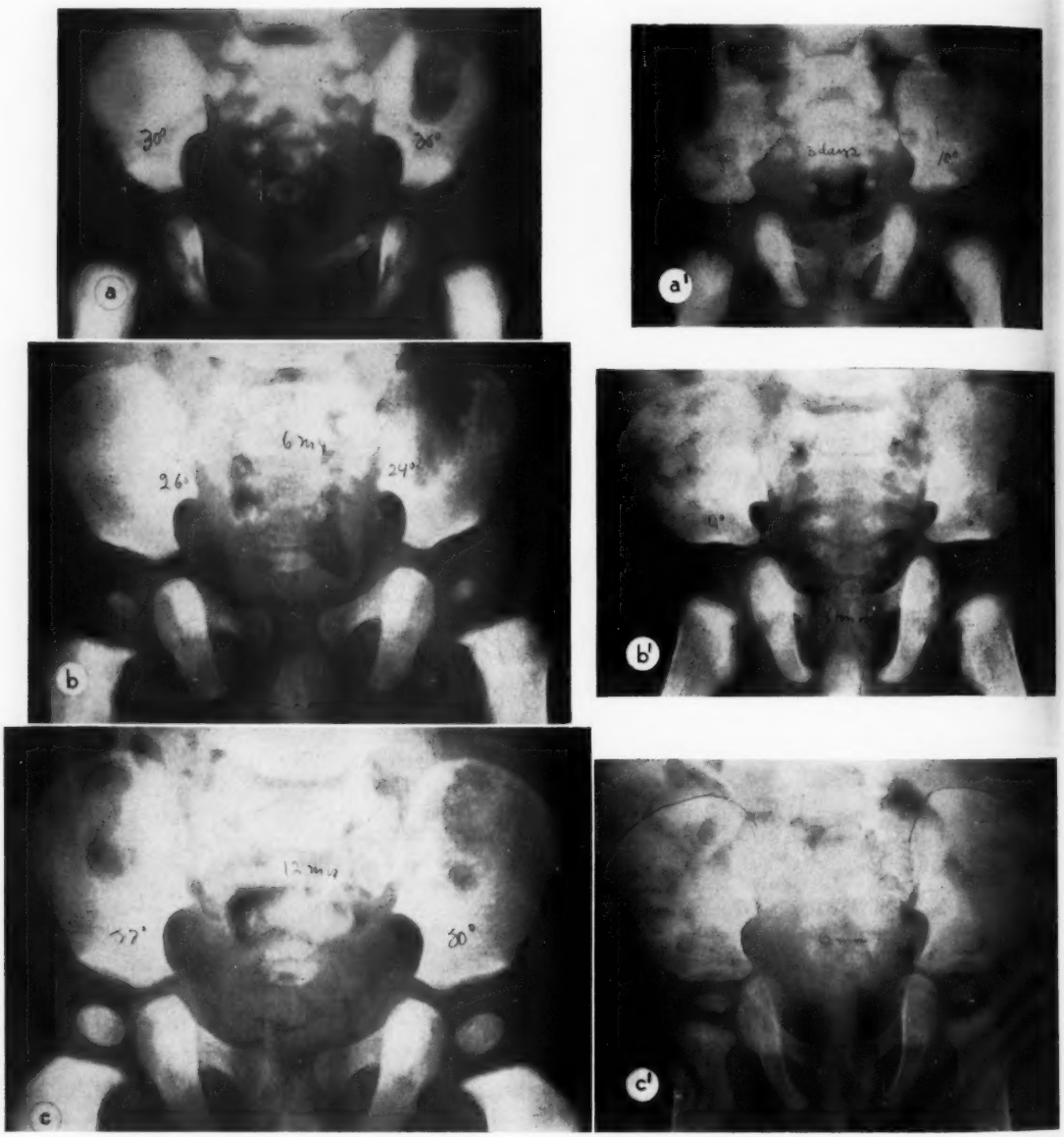

FIG. 3. Comparison of normal and mongoloid pelves at three days of age (*a* and *a'*), at six months (*b* and *b'*), and at twelve months (*c* and *c'*). At all ages the mongoloid pelvis is generally smaller than the normal; the iliac wings and bodies are shortened cephalocaudally and widened laterally, the greater sciatic notches are shallower and shortened cephalocaudally. The ischial bones on both sides begin to lose volume during the first six months and by the twelfth month, the ischial rami on both sides are elongated, slender and taper gradually in contrast to the heavy normal ischiums which taper sharply at their caudal ends. At all ages there are bilateral coxa valga deformities in the femurs which are not well shown in these prints because of the close cropping to save space. Measurements were as follows: mongoloid at three days, aa 8°–10°, ia 40°–38°, ix 48; at six months aa 4°–6°, ia 36°–30°, ix 40; at twelve months, aa 0°–0°, ia 34°–34°, ix 34. Normal at three days, aa 30°–30°, ia 60°–60°, ix 90; at six months, aa 26°–24°, ia 47°–58°, ix 82; at twelve months, aa 22°–20°, ia 62°–63°, ix 82 (aa = acetabular angle; ia = iliac angle; ix = iliac index).

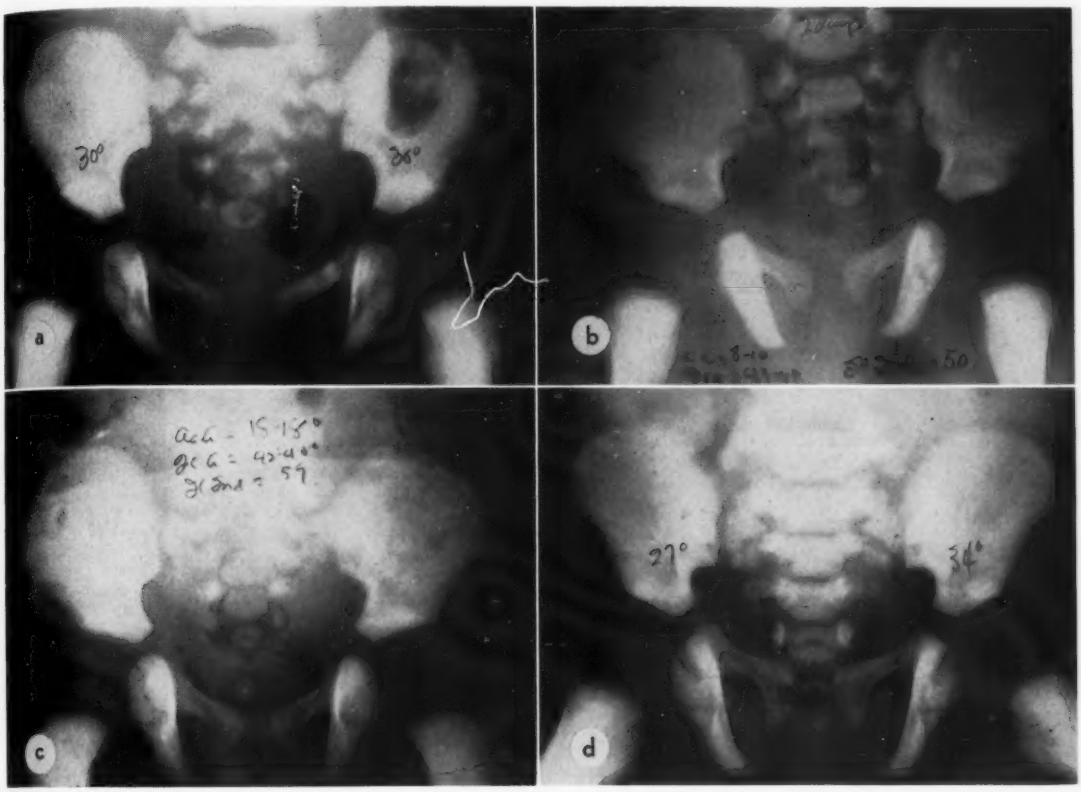

Fig. 4. Different degrees of mongoloid pelves during early infancy. (*a*) Normal pelvis at three days of age: aa 30°–30°, ia 60°–60°, ix 90. (*b*) Mongoloid pelvis at two days of age; the changes are typical and severe: aa 8°–10°, ia 43°–40°, ix 50. (*c*) Mongoloid pelvis at two days of age; the changes are typical but moderate: aa 18°–18°, ia 42°–40°, ix 59. (*d*) Pelvis of a mongoloid seven days of age with no diagnostic changes: aa 27°–34°, ia 56°–59°, ix 83. In this pelvis there are not even mild suggestive mongoloid changes, although the patient had many severe clinical stigmas and grew into a typical mongoloid imbecile. This is the only one of 48 mongoloid infants in whom the findings were normal in the pelvis, which is an incidence of about 2 per cent. The nasal bones of this patient were well developed and mineralized, and there was no dysplasia in the phalanges in the hands.

ness in the mongoloid scores throughout the first year; and with a single exception, one newly born mongoloid girl, the entire mongoloid distributions are confined to the smaller halves of the normal frequency distributions in all three categories of acetabular angles, iliac angles, and iliac indices. The probability is infinite that the smaller mongoloid values do not represent chance selection in a normal population. It is clear in the scatter of the mongoloid scores that they vary substantially; the coefficients of variation for the mongoloids were consistently higher than in normals in both younger and older groups in all categories. The average coefficient of variation for the mongoloids of all ages in all categories was 21, and for normals 13.

In this group of 48 mongoloids, there were no significant differences between boys and girls; this denies our earlier opinion, after a study of only 18 mongoloids, that the pelvic changes were more marked in mongoloid boys. In this second study of a larger group and especially an older group of mongoloids, it is evident that bilateral smallness in the girth of ischial rami, both superior and inferior, is a common and an important diagnostic change. We do not yet have adequate material or an accurate method for the quantitative evaluation of this feature. In older mongoloids also, bi

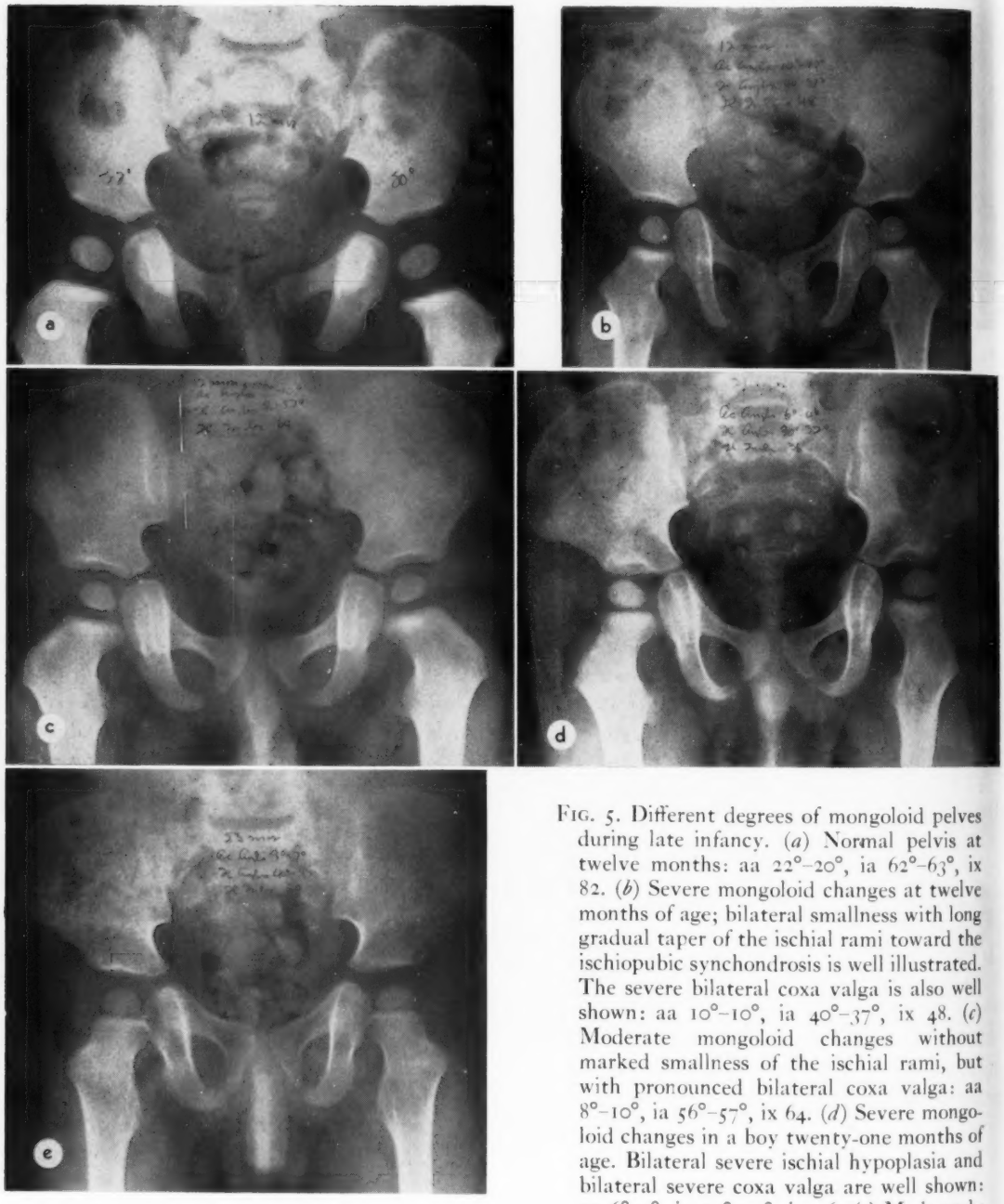

FIG. 5. Different degrees of mongoloid pelves during late infancy. (*a*) Normal pelvis at twelve months: aa 22°–20°, ia 62°–63°, ix 82. (*b*) Severe mongoloid changes at twelve months of age; bilateral smallness with long gradual taper of the ischial rami toward the ischiopubic synchondrosis is well illustrated. The severe bilateral coxa valga is also well shown: aa 10°–10°, ia 40°–37°, ix 48. (*c*) Moderate mongoloid changes without marked smallness of the ischial rami, but with pronounced bilateral coxa valga: aa 8°–10°, ia 56°–57°, ix 64. (*d*) Severe mongoloid changes in a boy twenty-one months of age. Bilateral severe ischial hypoplasia and bilateral severe coxa valga are well shown: aa 6°–4°, ia 30°–33°, ix 36. (*e*) Moderately severe changes in a boy mongoloid twenty-three months of age with exception of the ischial rami which have relatively large caliber and normally short taper. The changes in the iliums, however, are pronounced: aa 9°–7°, ia 40°–45°, ix 50.

Fig. 6. Mongoloid pelves in older children after closure of the ischiopubic synchondroses. (*a*) In a mongoloid boy six years of age the iliac wings are widened (ia 40°–45°), the ischial rami, however, are not hypoplastic but there is bilateral coxa valga. (*b*) In a mongoloid girl twelve years of age the iliac wings flare widely and the ischial bones are both small with elongated slender ischial rami. Moderate valga deformities are evident in both femurs.

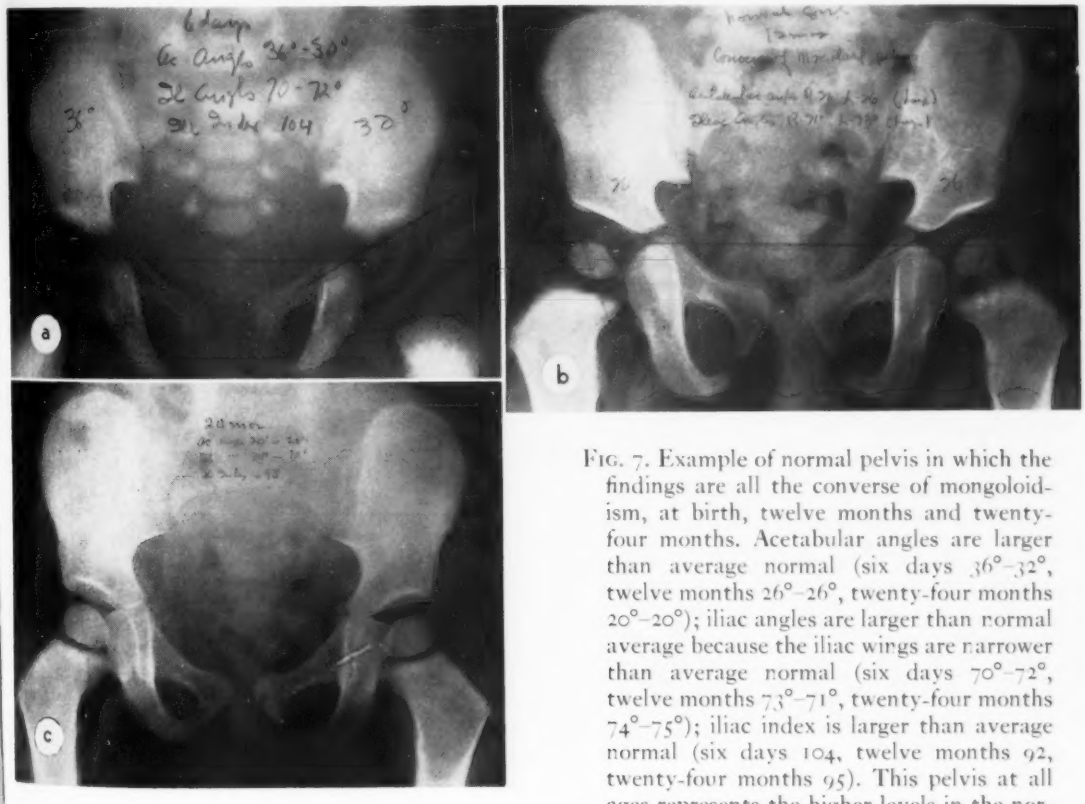

Fig. 7. Example of normal pelvis in which the findings are all the converse of mongoloidism, at birth, twelve months and twenty-four months. Acetabular angles are larger than average normal (six days 36°–32°, twelve months 26°–26°, twenty-four months 20°–20°); iliac angles are larger than normal average because the iliac wings are narrower than average normal (six days 70°–72°, twelve months 73°–71°, twenty-four months 74°–75°); iliac index is larger than average normal (six days 104, twelve months 92, twenty-four months 95). This pelvis at all ages represents the higher levels in the normal frequency distribution. We have never seen a normal pelvis of this type in a mongoloid. Also the ischial rami are normal and there are no valga deformities in the femurs.

TABLE II

MEAN VALUES, STANDARD DEVIATIONS, 2 STANDARD DEVIATION RANGES AND ACTUAL RANGES FOR ACETABULAR ANGLES, ILIAC ANGLES AND ILIAC INDICES IN THE YOUNGER AND OLDER GROUPS OF MONGOLOID INFANTS AND IN YOUNGER AND OLDER NORMAL INFANTS

Category	Mean	SD	2 SD Range	Actual Range
Acetabular Angles in Degrees				
Younger Mongoloids	16	4.5	25–7	29–9
Younger Normals	28	4.7	37–18	44–12
Older Mongoloids	11	4.2	19–3	19–6
Older Normals	22	4.2	8–14	34–8
Iliac Angles in Degrees				
Younger Mongoloids	44	6.5	56–30	58–35
Younger Normals	55	5.5	66–44	67–43
Older Mongoloids	41	7.0	55–29	50–26
Older Normals	58	7.0	72–43	74–44
Iliac Indices				
Younger Mongoloids	60	9.9	80–49	87–48
Younger Normals	81	8.0	97–65	97–68
Older Mongoloids	50	9.6	67–29	67–33
Older Normals	79	9.0	96–60	101–62

Younger means younger than three months; older means three months to twelve months of age. SD = Standard deviation.

lateral coxa valga in some degree appears to be present consistently, and to a severe degree in most of them. It seems reasonable that the smallness of the ischial rami and the coxa valga both represent hypoplasia and deformity of disuse in mongoloid infants who have weak, hypotonic pelvic and thigh musculature. We hope that the degree of these changes can be correlated with muscular performance in a future study. Similar shrinkage of the ischial rami is seen in nonmongoloid patients who have weak muscles around the hips (Figs. 11). We also have the impression that the ischiopubic synchondrosis closes at an earlier age in mongoloid children. In the older mongoloid the general appearance in the pelvis is one of widening of the iliac upper pubic segment and smallness of the lower ischiopubic segment. The entire mongoloid pelvis is, of course, smaller than the normal pelvis, which is probably just a regional feature of the generalized dwarfism of mongoloidism.

Although there is a slight overlap of the quantitative measurements of the mongoloid pelvis and of the normal pelvis, clinical experience and our statistical data indicate that the roentgenographic findings in the pelves are clearly diagnostic in about 4 out of 5 mongoloids, suggestive in about 4 out of 20, and uncertain or normal in less than 1 out of 20. We wish to emphasize that a conclusive diagnosis can be made roentgenographically by inspection of the film alone, without recourse to measurements of the acetabular and iliac angles, in 3 out of 4 mongoloids. The specificity of the mongoloid changes appears to be high because we have never seen the full typical mongoloid combination of pelvic changes in normals, or in any other disease—bilateral flat acetabular angles, bilateral widened iliums, bilateral slender ischial

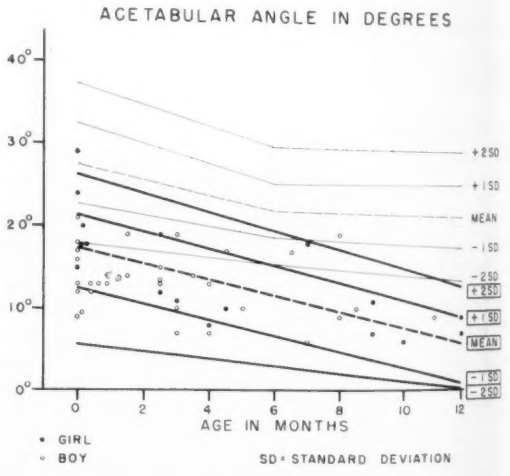

FIG. 8. Graphs of the scatter of individual scores for mongoloids and the superimposed ranges of variation of the mongoloids superimposed on the ranges of variation of normal infants, for the acetabular angles at birth, six months and twelve months. All of the mongoloid scores are less than the average for normals, save one; so that the overlap of mongoloids on normals equals approximately 2 per cent. The mongoloid scores otherwise were all confined to the smaller half of the normal distribution; 37 of the 48 mongoloid scores lie at or beyond the lower limit of the 2 SD range of normals. The heavier lines indicate the mongoloid values and the boxes enclose mongoloid labels.

rami and bilateral coxa valga. Although this complex has been confined to mongoloids, single elements of the complex are found in normals, and in association with some diseases. Small acetabular angles are found in some normal infants, but in them the other components of the mongoloid are absent.[2] In achondroplasia and the Ellis-van Creveld syndrome, the acetabular angles consistently approach zero (Fig. 12), and in some severe cases these angles may actually be reversed to minus zero; in these patients the iliac wings are small but the iliac angles are large. The iliac wings appear to be widened roentgenographically in conditions characterized by weakness of the abdominal musculature such as congenital absence of abdominal muscles in the Eagle syndrome, in exstrophy of the bladder, and in some cases of spina bifida in which there is regional abdominal paralysis. It seems likely that the roentgenographic widening of the iliac wings is due to their external rotation on their cephalocaudal axes at the sacroiliac joints rather than actual structural hypertrophy. These paralytic abdominal lesions have so little in common with mongoloidism clinically, that

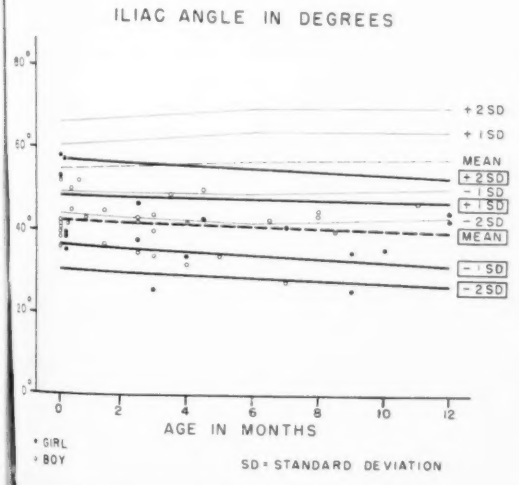

Fig. 9. Graphs for the scatter of individual scores for mongoloids and their frequency distribution superimposed on the normal frequency distribution for the iliac angles. The results are similar to those in Figure 8 with the exception that two scores in the newly born mongoloids are at and above the mean value for normals. This indicates an overlap of approximately 5 per cent. The graphs have a generally different contour from those of the acetabular angles because the values for normals increase with advancing age in contrast to the normal decrease with advancing age in the case of the acetabular angles.

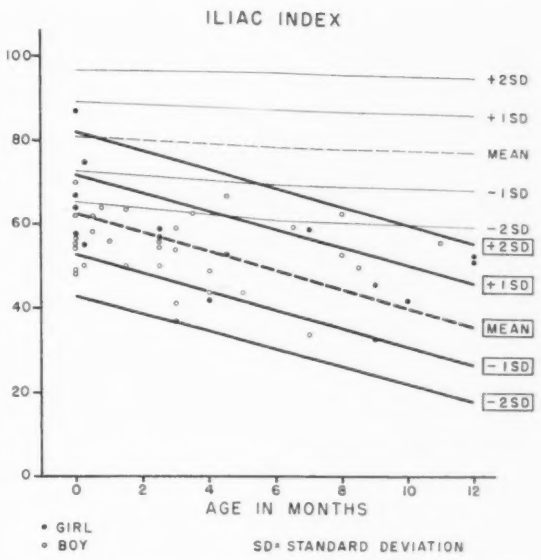

Fig. 10. Graphs of the scatter of individual mongoloid scores and their frequency distribution and variation superimposed on the normal distribution for iliac indices. The differences between mongoloids and normals are slightly more conspicuous in this category than in either acetabular angles or iliac angles.

Fig. 11. Severe atrophy and hypoplasia due to muscular disuse in a nonmongoloid girl eight years of age who suffered from spastic cerebral palsy and had had little or no use of the hips for years owing to spastic contractions in the muscles of the pelvis and thighs. In this patient the ischial hypoplasia is asymmetric—more marked on the right side.

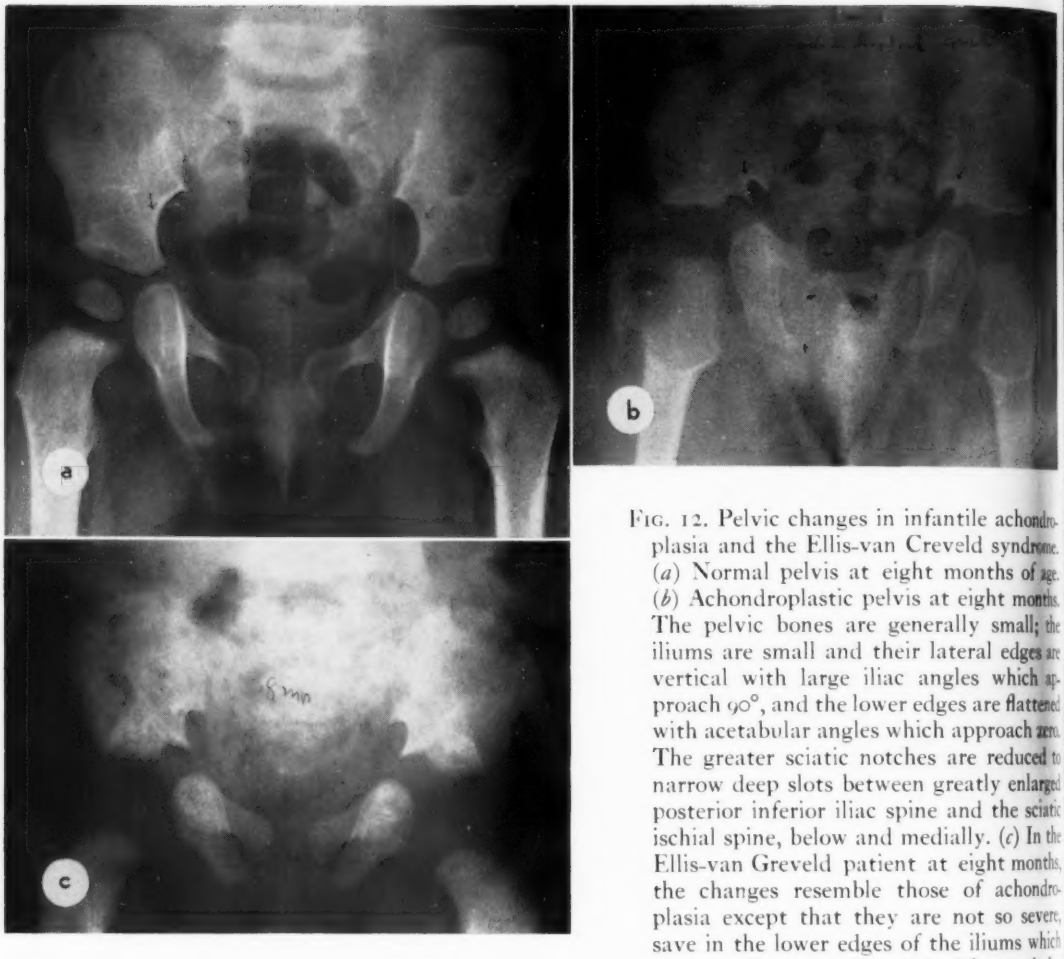

FIG. 12. Pelvic changes in infantile achondroplasia and the Ellis-van Creveld syndrome. (*a*) Normal pelvis at eight months of age. (*b*) Achondroplastic pelvis at eight months. The pelvic bones are generally small; the iliums are small and their lateral edges are vertical with large iliac angles which approach 90°, and the lower edges are flattened with acetabular angles which approach zero. The greater sciatic notches are reduced to narrow deep slots between greatly enlarged posterior inferior iliac spine and the sciatic ischial spine, below and medially. (*c*) In the Ellis-van Greveld patient at eight months, the changes resemble those of achondroplasia except that they are not so severe, save in the lower edges of the iliums which are actually convex caudad with acetabular angles which are less than zero.

FIG. 13. The pelvis in Hurler's syndrome (gargoylism) at twenty-four months (*b*); normal (*a*). The iliac wings and bodies are narrowed at all levels with deep constrictions at the junctions of wings and bodies. The tilted lower edges of the iliac bodies are short and the acetabular angles are large. The greater sciatic notches are normally deep and are elongated. The proximal ends of both femurs are shorter with severe coxa vara deformities.

differential diagnosis is no problem and besides, in the paralytic conditions, the acetabular angles are normal in size. In Hurler's syndrome (gargoylism), the pelvis is distinctive with high, narrow iliac wings and bodies, and enormous, deep acetabular depressions and high acetabular angles (Fig. 13). This is the converse of the mongoloid pelvis in several ways. The iliums in Morquio's disease usually resemble those of achondroplasia (Fig. 14); the acetabular angles are obliterated due to flattening of the caudal edges of the iliums, but the proximal ends of the femurs ossify slowly and inadequately.

FIG. 14. The pelvis in Morquio's disease at six years of age. The findings in the pelvis resemble those in achondroplasia with wide iliac wings and bodies, but short vertical (ventrical) lateral edges which cause larger iliac angles of approximately 90 degrees. The lower edges of the iliums are convex caudad with complete obliteration of the acetabular angles. The greater sciatic notch is greatly reduced with greatly enlarged sciatic ischial spines. The most striking difference from achondroplasia is in the proximal ends of the femurs which are non-mineralized in the heads and necks. The relatively high positions of the visible ends of the femoral shafts suggest that there is bilateral severe coxa vera.

SUMMARY

In 48 mongoloid infants twelve months of age and younger, the pelves presented a tetrad of characteristic roentgenographic findings which includes: (1) bilateral flattening of the lower edges of the iliums; (2) bilateral widening and flaring of the iliac wings; (3) bilateral smallness in caliber and gradual taper of the ischial rami; (4) bilateral coxa valga. The two last named features are not well developed prior to the sixth month of life.

This tetrad has not been seen by us in normal infants or in association with other diseases during infancy.

The pelvic roentgenographic findings are most pronounced and most conclusive during infancy when the clinical diagnosis of mongoloidism is most uncertain.

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SEVERE IDIOPATHIC HYPERCALCEMIA OF INFANCY*

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IDIOPATHIC hypercalcemia of infancy is a syndrome which has been recognized only recently.[2–8,10–12] Two main forms of the disease have been encountered.[2,3,10,11] Only one, the severe form, is of interest to the radiologist.

The mild form is the more common one and often referred to as "Syndrome I."[10] Clinically, these infants fail to thrive. The disease is transient and benign. The facies is normal. The blood pressure and cardiac findings are normal. There are no roentgen manifestations of osseous changes. Twenty per cent have renal acidosis. Serum calcium is 12–18 mg. per 100 ml. and blood urea is approximately 70 mg. per 100 ml. The blood chemistries return to normal with general improvement. No permanent mental or physical impairment is to be expected.

The clinical and chemical changes in the severe form, "Syndrome II,"[10] are similar but more marked. Only 15 cases have been described to date. The course is extremely prolonged and may be fatal. The roentgen changes are definite and form a characteristic pattern. If one follows the course of the disease by means of serial roentgenograms, changes can be seen to progress and regress. Therapy is not generally agreed upon as yet.[4,9]

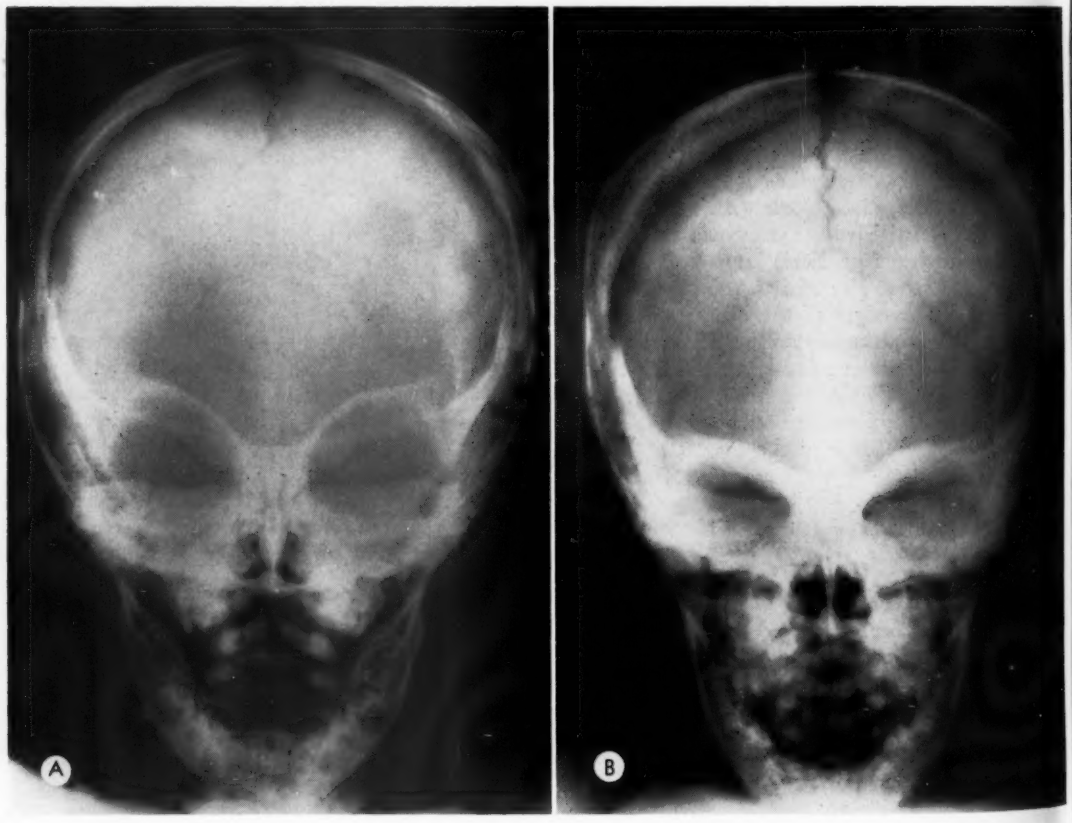

FIG. 1. Case 1. (*A*) Negative admission skull roentgenogram except for microcephaly. (*B*) Six months later, orbital rim and sphenoid bone sclerosis. Same findings were present at the base of the skull.

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REPORT OF CASES

Case 1. S. J. This was an eight month old female whose sibling had died of hydrocephalus. On January 4, 1956 (first University Hospital admission) she presented a two month history of vomiting, coughing, and irritability. She had borderline cyanosis associated with a Grade III systolic murmur to the right of the manubrium. Her musculature was hypotonic. She was microcephalic and mentally retarded. Laboratory findings: Blood urea nitrogen 43 mg. per cent, urinalysis negative, calcium normal on two occasions.

On August 3, 1956 the patient was admitted for the second time. Hypertension (135 to 160 /80) developed in the interim as did azotemia, hypercalcemia, and hyperphosphaturia. Her diet had been limited to milk and vitamins. She exhibited hypotonia and right breast hypertrophy. Her murmur persisted. She had one seizure after hospitalization. Laboratory findings: Hemoglobin 11 gm., white blood cell count normal, sedimentation rate 55 mm./hr.; urine acid, specific gravity 1.014; calcium 12 mg. per cent, phosphorus 5.5 mg. per cent, blood urea nitrogen 48 mg. per cent; CO_2 29 mEq.; chlorides 104 mEq., sodium 142 mEq., potassium 4.7 mEq.; alkaline phosphatase 13.8 Bodansky units; insulin clearance 4.2 cc./min.; blood phosphorus 0.035 mg./cc., phosphorus filtered 0.146 mg./min., phosphorus clearance increased with only 34 per cent resorbed (normal 90 per cent). Normal parathormone test and vitamin A tolerance test response, normal electrolyte and acid-base balance.

Fig. 2. Case 1. Sclerotic proximal humeral metaphyses, glenoid fossae and peripheral cortex; also epiphyseal "rings." Borderline rib sclerosis.

Fig. 3. Case 1. Vertebral peripheral cortical sclerosis. Ring sclerosis of sternal ossification centers.

On January 3, 1957 the patient was admitted for the third time. She now had bladder and renal calculi. The irritability, vomiting, and wasting continued. Laboratory findings: Blood pressure 125/80; calcium 11–14 mg. per cent, phosphorus 5 mg. per cent, alkaline phosphatase 18.2 Bodansky units, potassium 5.2 mEq., hemoglobin 11.7 gm., blood urea nitrogen 27 mg. per cent, CO_2 20 mEq., chlorides 97 mEq., sodium 137 mEq.; presence of acetone in urine. Normal parathormone response. At this time cortisone therapy was started.

FIG. 4. Case I. (*A*) Admission roentgenogram of the urinary tract. Vertebral peripheral cortical sclerosis; peripheral bands of sclerosis in the iliac bones and acetabula; femoral epiphyseal "rings;" and metaphyseal sclerotic bands. (*B*) Roentgenogram of the pelvis and femora one year later shows presence of peripheral iliac zones of sclerosis but clearing of acetabular and epiphyseal densities. Distal femoral undertubulation persists as do the linear sclerotic bands. Incidental finding is that of bladder calculus.

On April 14, 1957 the patient was hospitalized for the fourth time. The emesis was controlled temporarily by thorazine medication. The patient was then given vitamin D in doses of 300 units daily for ten days. Laboratory findings: Calcium 10.8 mg. per cent, phosphorus 4.6 mg. per cent, potassium 5.1 mEq., sodium 143 mEq., blood urea nitrogen 19 mg. per cent, CO_2 25 mEq., chlorides 107 mEq.

On May 1, 1957 the patient was admitted to the hospital for the fifth and last time. There was no clinical change. She was again placed on vitamin A in doses of 500 units daily and vitamin D in doses of 250 units daily. The cortisone was discontinued. Laboratory findings: Calcium 9.2 mg. per cent, phosphorus 4.4 mg. per cent, alkaline phosphatase 31.2 Bodansky units. Normal parathormone response.

Roentgenographic findings. Skull: Initially normal except for microcephaly. Later sclerosis of sphenoid and orbital ridge (Fig. 1, *A* and *B*). Sternum: Ring density of ossification centers (Fig. 3). Spine: Dense cortical peripheral sclerosis (Fig. 3 and 4) which later diminished. Long bones: Initially showed dense metaphyses with growth lines with intermediate translucent zones simulating resorption (Fig. 2 and 4*A*). There was undertubulation (Fig. 4*B*). Last examination showed diminution of sclerosis in proximal femora (Fig. 4*B*). The cortices exhibited increased density. There was stationary sclerosis of the proximal humeri (Fig. 2) and the epiphyses showed "rings." Short bones: Cortical and distal sclerosis (Fig. 5, *A* and *B*). Pelvis: Cortical rings and dense acetabula (Fig. 4*A*). A bladder calculus was also present (Fig. 4*B*). Scapulae: Cortical "rings" and dense glenoid (Fig. 2).

CASE II. M. V. This ten month old male was admitted to Children's Hospital, St. Paul, Minnesota, on April 23, 1957 and transferred to the University of Minnesota Hospitals on May 18, 1957. At the age of seven months, vom-

Fig. 5. Case 1. (*A*) First roentgenogram of the hand and wrist shows distal metacarpal and proximal phalangeal sclerotic bands with generalized cortical sclerosis; also, carpal center rings, and radial and ulnar metaphyseal peripheral sclerotic zones. (*B*) One year follow-up roentgenogram shows partial regression of sclerotic changes.

iting, irritability, constipation, and weight loss began. He was microcephalic and had a flat nasal bridge. The abdomen was soft. His musculature was hypotonic. Laboratory findings: Blood urea nitrogen 26 mg. per cent, CO_2 26 mEq., sodium 146 mEq., potassium 4.1 mEq., calcium 14.6 mg. per cent, phosphorus 3.9 mg. per cent, alkaline phosphatase 15.2 Bodansky units, total serum proteins 7.2 gm., albumin 3.5 gm., globulin 3.7 gm., hemoglobin 10.6 gm., white blood cells 13,600, sedimentation rate 35 mm./hr. Urinalysis: specific gravity 1.010, pH 6, albumin trace, sugar negative, red blood cells 2 plus, coarse granular casts. Electrocardiogram: Increase in P-R interval. Urinary nitrogen 2.7–3.6 gm./24 hr., phosphorus 275–372 mg./24 hr., calcium 42–88 mg./24 hr.

Roentgenographic findings. Skull: Normal (Fig. 6). Spine: Peripheral sclerotic cortical margins (Fig. 8 and 9). Long bones: Epiphyseal rings, metaphyseal sclerosis, some diffuse and some linear with translucent zones (Fig. 7, 9 and 10). Short bones: Similar metaphyseal cortical and metaphyseal sclerosis (Fig. 11). Flat bones: Pelvis and scapulae showed peripheral as well as glenoid and acetabular sclerosis (Fig. 7 and 9).

DISCUSSION

In general, the clinical and laboratory findings may be summarized as follows:[4,10,11] The age of onset was six to seven months with vomiting, wasting, constipation, thirst, polyuria, and dehydration. Underdevelopment, retardation, peculiar facies, heart murmur, hypotonia, apathy, irritability, hypertension, and hyperreflexia were present. It has been difficult to exclude primary renal acidosis. Serum calcium and blood urea nitrogen were raised. Phosphorus alkaline phosphatase, chloride, and bicarbonate levels were normal.

FIG. 6. Case II. Normal roentgenogram of the skull.

Plasma proteins were increased (alpha and gamma globulins). Daily calcium and phosphorus retentions were normal. Early urinary calcium level was normal and late levels were elevated. Renal function was depressed but did return to normal in one case. One case had renal calculi. The parathyroid glands and vitamin D intoxication were not incriminated.

Based on serial studies, we feel that the roentgen findings are characteristic and that, together with the clinical and laboratory features, they establish this condition as a separate entity. The clinical and laboratory features help differentiate idiopathic hypercalcemia from heavy metal intoxication, osteopetrosis, myelofibrosis, hyperparathyroidism, hypoparathyroidism, hypervitaminosis A and D, rickets, and renal acidosis.[1,13]

In our cases, the characteristic bone changes were noted, but they were not stable as one may suspect. In Case I, the skull at the beginning was negative except for microcephaly. At a later date, the typical sclerotic changes in the sphenoid and the base of the skull appeared (Fig. 1*B*). The flat bones (scapulae and pelvis) showed peripheral linear sclerotic bands and dense glenoid and acetabular fossae (Fig. 2 and 4*A*). The acetabular sclerosis gradually regressed (Fig. 4*B*). The spine exhibited typical peripheral cortical sclerosis. The long bones showed a combination of generalized metaphyseal sclerosis and linear metaphyseal sclerosis alternating with translucent zones, failure of tubulation, and epiphyseal rings (Fig. 2 and 4, *A* and *B*). The sternal centers and short bones showed similar changes (Fig. 3 and 5, *A* and *B*).

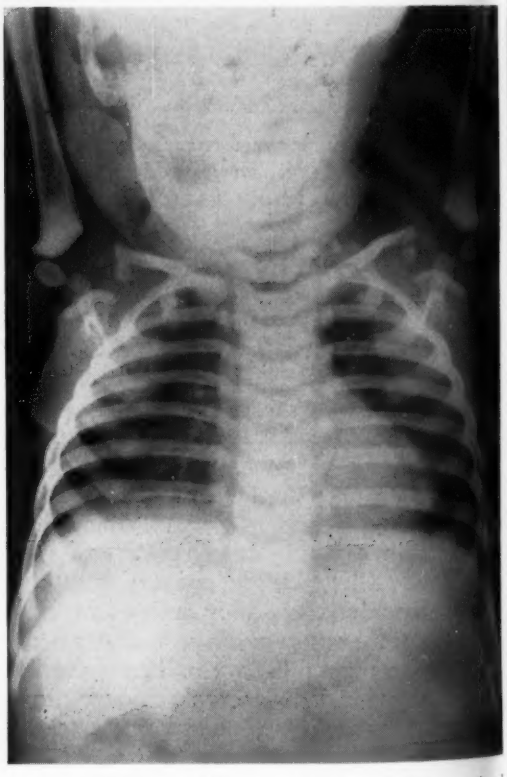

FIG. 7. Case II. Diffuse sclerosis of the proximal humeri with epiphyseal "rings," sclerosis of the glenoid and peripheral scapulae, and borderline rib changes.

The instability of the bone changes, as demonstrated roentgenographically, is associated with the constantly changing metabolic state. This finding is of additional aid in differentiating idiopathic hypercalcemia of infancy from other similar bone lesions.

SUMMARY

Two new cases of severe idiopathic hypercalcemia of infancy are presented and their roentgenographic features discussed. Areas of sclerosis in the metaphyses of long bones as well as of the short bones, vertebral cortical sclerosis, and epiphyseal rings are characteristic. The instability of these changes, dependent on the metabolic state, is of additional aid in the differential diagnosis from other similar bone lesions.

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Fig. 8. Case 11. Roentgenogram of the spine shows characteristic peripheral sclerotic margins.

Fig. 9. Case 11. Normal intravenous pyelogram. Characteristic spinal, iliac, acetabular, epiphyseal, and femoral metaphyseal sclerosis is obvious.

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FIG. 10. Case II. Long bone sclerosis with accentuation of metaphyseal sclerosis and translucent zones. Epiphyseal "rings" are present.

FIG. 11. Case II. Roentgenogram of the hand and wrist shows sclerosis and translucent zones of the distal radius and ulna, sclerotic rings of the carpal centers and sclerotic bands of the short bones.

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AGAMMAGLOBULINEMIA*

A CASE REPORT AND DISCUSSION

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AGAMMAGLOBULINEMIA, an apparently isolated disturbance of protein metabolism, is today a well established clinical entity, with clear criteria for diagnosis and treatment. As with many other conditions, the radiologist's use of indirect evidence may provide the first definitive clue, and even make the difference between proper diagnosis and no diagnosis.

REPORT OF A CASE

P. H., a three and one-half year old white male, was admitted to Vanderbilt University Hospital with a history of high fever and cough intermittently for one month.

Repeated septic infections characterized the past history. Beginning at six months of age, the patient had at least five separate episodes of pneumonia, intermittently draining ears, and multiple vesicular and papular skin lesions.

Family history revealed nothing unusual about the patient's parents. The patient had four sisters, living and well, and three older brothers. Two brothers were dead, one at the age of thirteen months with "cough, draining ears, sores, and fever," and the other at five months with "brain fever." The surviving male sibling (aged eight) had had an unusual number of pulmonary infections but an otherwise normal history. His gamma globulins were at the lower limit of normal.

On physical examination, a small, poorly nourished, male child was seen with ears full of purulent exudate and chest findings of patchy pneumonia. No abnormal lymph nodes were palpated and no pharyngeal tonsils were identified. The spleen and liver were slightly enlarged.

Roentgenographically, the chest and skull were of interest. The chest showed evidence of chronic pulmonary infection with partial left lower lobe shrinkage, markedly coarse bronchovascular markings, and moderate, diffuse emphysema (Fig. 4). The lateral skull roentgenogram revealed a curious absence of pharyngeal soft tissue, producing a wide open air space, limited only by sphenoid above and soft palate below. Since there was no history of tonsillectomy and adenoidectomy, the absence of pharyngeal lymphoid tissue in a child this age was explainable by the diagnosis of agammaglobulinemia (Fig. 3). This was confirmed by serum electrophoresis and paper chromatography, which showed only negligible amounts of gamma globulin.

DISCUSSION

Agammaglobulinemia was first described in 1952 by Bruton,[1] who discovered an absence of the plasma gamma globulin fraction in an eight year old boy with a history of repeated severe infections of various kinds. Since that time, nearly 100 other cases have been reported.

Two principal forms of this condition exist. In the congenital form, exemplified by Bruton's original case, a sex-linked recessive trait is apparently responsible. This form occurs only in males and is transmitted by females. To date, no convincing exceptions have been observed. The condition is characterized by repeated bouts of sepsis, beginning shortly after birth. The history frequently reveals male siblings who have died at an early age due to overwhelming infection, although not necessarily all male siblings are affected.

The second form is "acquired" agammaglobulinemia, although how it is acquired is not known. This form occurs in both sexes, and at any age, with septic histories varying in length from a few months to many years. Bronchiectasis is, perhaps, the most frequent complication in the acquired form. Otherwise, the findings in the two forms are quite similar. In both, a basic inability on the part of the body to produce the normal amount and type of gamma globulin is

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Fig. 1. "Normal" child's pharyngeal region.

observed. This prevents antibody formation because the normal precursor is lacking, and the clinical picture of poorly tolerated infections develops. The lack of gamma globulin is probably secondary to the deficiency of plasma cells, also a constant finding in this disease. It is now widely accepted that all or most of the body's gamma globulin is formed by plasma cells. Hence, the basic defect is probably one of abnormal reticulum cell function, although other aberrations of reticulum cell maturation, apparently unimportant clinically, are also noted. No response is elicited by various types of antigenic stimulation. For this reason, it is not surprising that the agammaglobulinemic patient accepts skin homotransplants about as well as he does autotransplants, and that he tolerates all blood cell types for transfusion.

Neither the plasma cell nor the gamma globulin deficiency is absolute; relatively minute amounts of both are found in congenital and acquired forms, usually using more sensitive detection methods.

The clinical picture of this disease is dominated by four major factors, as described by Good and Varco:[6] (1) increased susceptibility to bacterial infection; (2) absence of gamma globulin from the serum; (3) absence of antibodies from blood and tissues; and (4) failure of antibody production in response to antigenic stimulation.

The respiratory apparatus is perhaps the most frequently involved and all cases reported in the literature showed one or several forms of pneumonia and its complications. Nothing characteristic of agammaglobulinemia *per se* is seen, however. Other infections frequently encountered include otitis media, mastoiditis, recurring meningitis, septicemia, purulent sinusitis, bacterial intestinal and urinary infections, and severe pyogenic skin lesions. Pneumococcus, Streptococcus, Staphylococcus, and Hemophilus influenzae are the organisms most frequently encountered.

A great difference exists between the virulence of viral and bacterial infections in agammaglobulinemia. Virus diseases are frequently seen to run an apparently normal course, and some resistance to recurrence is developed in most cases. Yet antibodies to virus diseases are not demonstrable by conventional methods. Good and his co-workers[6,7] concluded that the minute amounts of gamma globulin known

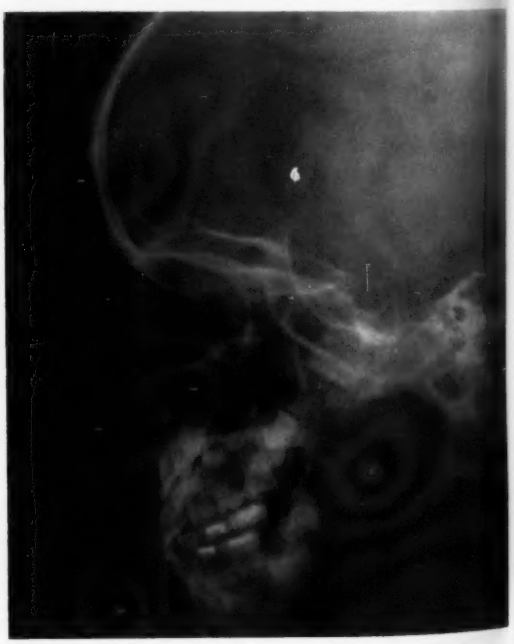

Fig. 2. Roentgenographic appearance with hypertrophied pharyngeal lymphoid tissue.

to be present must be adequate to provide sufficient antibodies for viruses but not for bacteria, or else that some unknown virus protection mechanisms exist.

Qualitative or quantitative aberrations of serum gamma globulin leading to decreased antibody formation are seen with several apparently unrelated conditions. A normal hypogammaglobulinemia occurs in early infancy before independent immunizing mechanisms are developed. Occasionally, this period may be prolonged, leading to an increased incidence of infection. Protein depletion itself is ordinarily not accompanied by dangerously low gamma globulin levels, and it is only in very advanced nephrosis and extreme starvation that levels fall so low as to interfere with antibody formation. A qualitative failure of normal antibody formation is seen with quantitatively normal or elevated gamma globulin in occasional cases of multiple myeloma and has been postulated in other situations.

Agammaglobulinemia from a roentgenologic standpoint has few special features;

Fig. 3. "Neuhauser's sign" showing the strikingly wide pharyngeal air column with agammaglobulinemia.

Fig. 4. Chest in agammaglobulinemia. This roentgenogram was made in an asymptomatic interval and shows evidence of left lower lobe shrinkage and chronic diffuse pulmonary infection.

however, the radiologist's opportunity to see the manifestations of multiple abnormally tolerated infections may be excellent. In addition, in the congenital cases one simple sign exists which is almost diagnostic. This was first observed by Neuhauser.[11] Because of the scanty formation of lymphoid tissue (secondary to the plasma cell deficiency), the pharyngeal air space, normally partially occupied by the tonsils and adenoids, is abnormally large. This is perhaps best demonstrated on a well centered lateral roentgenogram of the nasopharynx, and the difference in agammaglobulinemia from the normal range and from those with hypertrophied lymphoid tissue is striking enough to be useful (Fig. 1–3). In older children and adults, the frequency of normal atrophy invalidates this finding, as does, of course, the history of a tonsillectomy and adenoidectomy.

SUMMARY

1. Agammaglobulinemia is a disease characterized by almost complete absence of serum gamma globulin. This is probably secondary to deficient plasma cell formation.

2. Because of the gamma globulin deficiency, antibody formation in these patients is almost absent. This produces the clinical picture of poorly tolerated infections.

3. One reasonably specific roentgen sign exists in young children without history of tonsillectomy and adenoidectomy. This consists of a markedly enlarged pharyngeal air column.

4. Remaining roentgen findings comprise multiple nonspecific manifestations of infection.

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MAFFUCCI'S SYNDROME*

DYSCHONDROPLASIA WITH HEMANGIOMATOSIS REPORT OF A CASE

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THE association of dyschondroplasia (non-hereditary mesodermal dysplasia —Ollier's disease) with hemangiomatosis was first described by Maffucci in 1881. It was presented in the American literature by Krause[3] in 1944.

A review of the literature indicates that 23 cases have been reported to date. Mild degrees of this syndrome are probably more common than the reported small number of cases would indicate. Umansky[6] (1946) described a mild case at the Hospital for Joint Diseases, New York City, in a colored girl and noted that no other cases were found in 71 cases of hemangiomata, 65 cases of dyschondroplasia, and 60 cases of osteochondromata collected in fifteen years.

Defects in cartilage bone formation (dyschondroplasia) with vascular hamartomata (mesodermal dysplasia), when occurring together, constitute an entity even though their association is purely coincidental.

Jacobson[2] (1940) in a critical review of the inter-relationships of osteogenic tumors brings forward morphologic and genetic evidence to support the view that dyschondroplasia (enchondromatosis) and diaphyseal aclasis (multiple hereditary osteochondromatosis) should be regarded as distinct entities.

Dyschondroplasia affects the growing ends of bone. Normal ossification does not take place. As the bone increases in length, areas of cartilage which fail to ossify persist in the metaphyses. Dwarfing of the affected limbs with deformity occurs. It is often unilateral and markedly asymmetrical. The bones most affected are the long bones, including the bones of the hands and feet. In the phalanges multiple enchondromata are noted.

At birth the child is normal. By the twelfth year a hard nodule appears, about 1 to 2 cm. in diameter, commonly at a finger or toe, which is then followed by other nodules. The lesions are more or less unilateral. Pathologic fractures are a feature. A deformed dwarf may result with huge massses of tumors of the hands and feet. The hard nodules represent enchondromata.

The vascular component consists of multiple cavernous hemangiomata and phlebectasia. They occur in the subcutaneous tissues anywhere. They present themselves as blue or reddish-blue tumors that are soft, compressible and sometimes tender. Thrombi lead to calcifications (phleboliths) which are diagnostic roentgenographically.

The age distribution of the reported cases is eight to fifty-eight years. The cases usually become evident clinically at or before puberty. The deformity is stationary after full growth. Most patients are short with poorly developed musculature, and have average intelligence.

Amputation is necessary in one half of the patients. Chondrosarcoma was reported in 4 cases. Abnormal sweating and vitiligo may be present. An associated cerebral glioma has also been reported.

REPORT OF A CASE

V.A., a forty-four year old white male, was admitted to University Hospital with a complaint of a soft tissue tumor in the left palm of thirteen years' duration.

In 1929, at the age of sixteen, the patient had a deep laceration of the palm which was su-

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FIG. 1. (*A* and *B*) There is a large enchondroma at the base of the proximal phalanx of the index finger as well as a small enchondroma at the base of the terminal phalanx of the ring finger. A large soft tissue mass is present on the lower aspects of the metacarpal region containing several round calcifications with central vacuoles (phleboliths) diagnostic of an angioma.

tured. In 1944 he developed a small tumor in the palm which increased in size. During the past two years this increase in size had been more rapid.

There was also progressive enlargement of the distal phalanx of the left thumb since 1944.

One year prior to admission he fractured the distal phalanx of the left ring finger. Since then it has become swollen and deformed. The remainder of the history was not contributory.

On physical examination there was a soft tissue mass involving the left hypothenar and thenar eminences and part of the lower wrist. The mass was multilobulated and measured over 3 inches in its maximum diameter. Enlarged racemose plexuses were visible under the skin. Several areas of the tumor were cystic-like in consistency. The skin moved freely over the mass and there was no involvement of the tendons.

The distal phalanx of the left ring finger was deformed and the distal phalanx of the index finger was enlarged and thickened.

Roentgenographic Examination. A large soft tissue mass was present on the palmar aspect of the metacarpal region, measuring roughly 7 cm. in diameter and 5 cm. in depth. Within this mass were small round calcifications (phleboliths) indicative of an angioma. An enchondroma was present in the proximal phalanx of the index finger with expansion of the distal two-thirds of the phalanx with irregular trabeculation and calcification. Another small chondroma was present in the terminal phalanx of the fourth finger of the same hand.

On April 29, 1957 the soft tissue mass was excised.

Pathologic Report. The soft tissue mass, measuring 8×7×3.5 cm. was coarsely lobulated and covered by a layer of fibrous tissue.

It was firm in consistency and had a fibrous appearance. Microscopically, there were numerous groups of capillary blood vessels separated by bands of fibrous tissue. The endothelial cells lining the capillaries had plump uniform oval nuclei. The fibrous tissue showed an extensive degree of focal infiltration with chronic inflammatory cells. The pathologic diagnosis was capillary hemangioma of the hand showing fibrosis and chronic inflammation.

SUMMARY

A case of dyschondroplasia and hemangiomatosis (Maffucci's syndrome) is presented with a review of the pertinent literature.

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ROENTGENOGRAPHIC APPRAISALS OF SKELETAL GROWTH AND DEVELOPMENT*

RELIABILITY AND INFLUENCING FACTORS

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THE constantly changing skeletal structure of children reflects the successive stages of their growth and development. Under the control of the growth impulse, with its steady progress toward maturity, there are (1) increases in bone size and (2) adaptations or development within the growing bone due to changes in cell complexity and successive modeling of the bone cortex, especially in the joint regions. Other changes, not permanently recorded, such as degree of mineralization, take place in the skeletal tissue. Although these changes and adaptations may proceed at different rates in various parts of the skeleton, they are measurable and thus indicative of skeletal growth and development.

To further the study of child development we need more knowledge of the relationship of skeletal maturation to chemical and physical growth of normal children and of the factors that influence their level and rate of change. In order to obtain basic facts regarding this relationship, we must not only have assessments of skeletal maturation but must be able to evaluate the reliability of these measurements.

The skeleton comprises 20 per cent of the body weight of an individual. Throughout life, changes occur in the number, size, and development of the individual bones of which it is formed. The bones can be measured in terms of (1) the individual's age at their first appearance, (2) actual and relative amounts of bone area and bone diameter, and (3) degree of bone development, as indicated by well defined and irreversible stages of bone contour.

Roentgenograms provide a means of measuring skeletal growth, development, and degree of mineralization. Roentgen rays are restricted, however, to two dimensions as in a silhouette, and for practical reasons assessments are limited to the specific areas of the skeleton for which standards have been developed. Nevertheless, roentgenograms give a satisfactory means of observing skeletal growth and development *in vivo*.

The first application of the roentgenographic method of assessment of maturation pertained to age at first appearance of specific bones (Pryor,[10] Rotch[13]). Increase in size of the bones of the hand and wrist, both actual and in relation to size of the wrist, has been investigated in terms of surface area by Baldwin *et al.*[1] and by Flory,[2] and in terms of greatest diameter by Kelly.[4] Specific stages of bone development in terms of fusion of the epiphyses of the long bones with their diaphyses were recorded by Rotch[14] and Pryor,[11] and more recently the development of the short bones, such as the carpals and the tarsals, in addition to the long bones, has been measured by maturity indicators by Flory,[2] Todd,[15] Greulich and Pyle,[3] and Pyle and Hoerr.[12]

EXPERIMENTAL PROCEDURE

It was our privilege to have the guidance of distinguished scientists in the selection of children for the study, in the setting up of roentgenographic techniques and procedures, and in the assessment of roentgenograms. The measurements used in this study were all made by highly experienced

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investigators. Assessments were made from original films with the exception of those made from prints for the purpose of comparison.

Subjects. Seventeen boys and ten girls, aged three to fifteen years (thirty-four to one hundred and eighty-three months), were the subjects of the investigation. They were active, growing children living in a healthful environment and participating in school activities, and were judged to be clinically, physically, and mentally normal (Macy,[5,6,7] 1942, 1946, 1951).

Roentgenographic Technique. Roentgenographic procedures were carried out under the supervision of Dr. Lawrence Reynolds, roentgenologist of Detroit, in collaboration with the late Dr. T. Wingate Todd, and the staff of the Anatomy Department, Western Reserve University. The technique included standardization of (1) time of exposure and distance of the film from the roentgen-ray tube; (2) position of each of the six skeletal areas (hand, elbow, shoulder, foot, knee, and hip); and (3) processing and time of developing the films. A standard aluminum step-wedge was reproduced on the film as an additional device to equate the roentgenograms for assessing the density of the bones and also to serve as a check on exposure time and development of the films.

Standards of Reference. The two types of standards used in evaluating skeletal growth and development were (1) size of these bone centers, and (2) stage of development as indicated by bone contour. The standards of reference based on age at appearance of bone centers alone were not applicable in this investigation owing to the age range of the children.

(1) *Bone Size.* Actual and relative amounts of bone can be measured from roentgenograms in terms of surface area using a planimeter or differential analyzer, and in terms of diameters using calipers or rulers. For the present study, one of the authors (H.J.K.) applied the Baldwin Standard (Hand) of determining relative size of carpal areas in relation to wrist size (Coradi disk planimeter) and the Kelly Standard (Hand) of determining the greatest diameter of the carpals and epiphyses in relation to the wrist size (calipers).

(2) *Bone Development.* The Todd inspectional method of assessing skeletal developmental progress in the hand, elbow, shoulder, foot, knee, and hip areas was applied by Dr. Todd and Dr. C. C. Francis by the Todd Atlas (Hand) and unpublished atlases for the other regions. Each bone can also be assessed individually as a measure of skeletal development in accordance with changes in bone contour.

The standards of reference were based on the modeling of the bone cortex and were derived from the average age at appearance of certain successive intermediate features of the cortex. Dr. Todd designated specific steps in the maturation process as skeletal maturity determinators. His standard of reference consisted of a series of roentgenograms which illustrated for each bone center successive skeletal indicators found in every child before his skeletal structure attains its adult size and form. Each roentgenogram was selected because it was the best available representation of an over-all average of the individual bone centers consistent with a corresponding chronological age. The average used by Dr. Todd in setting up this series of roentgenograms for his standard was an inspectional average of the individual bone centers with greatest emphasis placed on the most advanced centers. This standard permits each bone center to be measured individually according to its stage of maturation. The speed at which these indicators replace each other is a measure of the skeletal development of individual bone centers, and the over-all average is a measure of the maturation of a skeletal area.

S. Idell Pyle, Ph.D., Western Reserve University, applied the Greulich-Pyle Standard to the hand roentgenograms of the children. This standard was developed from the Western Reserve roentgenograms including additional films collected after publication of the Todd[15] Atlas

(1937). This enlarged collection of films permitted the formulation of the Greulich-Pyle Standard entirely from longitudinal data. The standard consisted of a series of roentgenograms similar to the Todd Atlas (Hand) and also made use of maturity indicators. It differed, however, in that an anatomical mode and not an inspectional average was used. For purposes of comparison, Dr. Pyle recorded both the Todd inspectional average and the arithmetic mean for all the centers as the over-all skeletal rating for the entire hand area for each of the roentgenograms of our children.

RESULTS AND COMMENT

The data presented here serve to ascertain the reliability of some of the observations, the agreement of measurements of growth and development, and the influence of age, sex, and individual differences on the level and rate of change of skeletal maturation.

RELIABILITY OF SKELETAL ASSESSMENTS

In developing his classic Atlas of Skeletal Maturation (Hand), Dr. Todd emphasized the usefulness of the roentgenographic method for evaluating developmental progress of children. At the same time, he recognized that, even when properly used, the method had by no means attained the status of an exact science.

The reliability of skeletal measurements may vary with each standard and with each investigator as it is a measure of consistency and not of validity. In the interest of accuracy, Dr. Pyle furnished a random sample of her roentgenographic data for an evaluation of reliability in terms of the agreement of duplicate skeletal assessments, and Drs. Todd and Francis provided us with data for studying reliability in terms of the agreement of their independent measurements.

Duplicate Assessments. Three types of duplicate independent assessments were made by Dr. Pyle (Table 1): (1) Two readings of the original films were made under environmental conditions as nearly normal and equivalent as possible. (2) The first reading of the original films was taken under normal conditions, and the other under pressure of time; this time factor may influence the assessor emotionally and thus affect the value of the reading. (3) The first reading was taken from the original roentgenographic films, and the second from published prints of the same films (Macy,[6] 1946). The prints were of actual size but sometimes had to be trimmed in the printing process, which may have affected the over-all assessment of the bone area and thus accounts for some disagreement when the ratings were compared with those from the original untrimmed films. The interval between the two readings in any one set of measurements varied, sometimes being as long as two years.

The data on these duplicate ratings are given in Table 1, each value representing the frequency of the differences, expressed in months, between the two assessments of skeletal development. The second reading was always subtracted from the first; thus, a positive value indicates that the first reading was higher, and a negative value that it was lower. When the differences range about equally in both directions from zero, they may be considered as "chance" differences; when they are consistently above or below zero, they are most likely "systematic" differences.

The data indicate good agreement between duplicate assessments, the greatest single difference being four months. Even when observing the growth of an individual, a difference of four months would not be appreciable. The means, representing group values, indicate even smaller differences, of less than a month. The scatter suggests that the differences are not consistently positive or negative and thus may be due to chance. The assessments made on actual-size reproductions were identical with those made on the original films for 54 per cent of the cases. The remaining 46 per cent agreed within two months and in all but 3 cases is the result of partial deletion of phalanges from the reproduction. Two

TABLE I

AGREEMENT* OF DUPLICATE ASSESSMENTS OF SKELETAL MATURATION

Conditions	Frequency of Differences of								Mean Difference
	−3 mo.	−2 mo.	−1 mo.	0 mo.	1 mo.	2 mo.	3 mo.	4 mo.	mo.
Normal									
Todd Atlas†			1	9	1	1		1	0.5
Greulich-Pyle Atlas				4		3			0.8
Time pressure									
Greulich-Pyle Atlas	1	3	4	4	3	1	1		−0.3
Film versus print									
Greulich-Pyle Atlas		1	7	20	6	3			0.08

* First reading minus the second.
† Inspectional average. The arithmetic mean was applied to the Greulich-Pyle data.

of the 3 exceptions are poor reproductions and the third results from a film very difficult to assess inasmuch as skeletal development had nearly terminated.

It should be re-emphasized that these observations were made by a highly experienced scientist and that greater differences would be expected in readings by observers of less skill and training.

Assessments by Different Investigators. The independent assessments made by several investigators differed considerably more than the duplicate assessments made by one investigator. Table II presents the differences observed between ratings of two investigators using the Todd Standards for the hand and unpublished atlases for the foot, elbow, knee, hip, and shoulder. The degree of difference apparently varied for the six areas of the body. One would expect this difference to be influenced by the number of centers involved; better agreement in over-all averages would be expected for the skeletal regions (hand and foot), with the greater number of bone centers, owing to the balancing of chance differences. The fact that the data did not indicate this inverse relationship between agreement and number of centers involved may be due to the method used for assessing the over-all average for the area. The reverse might have been true if an arithmetic mean had been used rather than an inspectional average weighted by the advanced centers.

TABLE II

AGREEMENT* OF TWO INVESTIGATORS' ASSESSMENTS FOR SIX SKELETAL REGIONS

Skeletal Region	Frequency of Differences of					Mean Difference
	−12 through −8 mo.	−7 through −3 mo.	−2 through +2 mo.	+3 through +7 mo.	+8 through +12 mo.	mo.
Hand	1	6	51	2		−0.5
Foot	1	8	49	2		−0.6
Elbow		2	52	3	3	+0.5
Knee		7	50	3		−0.3
Hip		1	50	9		+1.1
Shoulder		6	51	3		−0.3

* Dr. Todd's assessment minus the assessment made by Dr. Francis.

The agreement between investigators was presented by Dr. Todd[15] (1937 Hand Atlas) by means of the correlation coefficient. There was good agreement, with age and sex held constant, between the ratings of Dr. Todd and Dr. Francis (0.845 to 0.978) for the knee and hand, but when their assessments were compared with those of another scientist who was relatively inexperienced, having had only one day training, the coefficients ranged from 0.621 to 0.923. Systematic and variable errors were discussed by Mainland.[8,9]

Although our data on both duplicate measurements and ratings of different assessors were based on the Todd or Greulich-Pyle Hand Atlas, the greater objectivity of the Kelly and Baldwin Standards presupposes at least an equal precision. The precision of duplicate measurements based on the Todd Atlases for the foot, elbow, knee, hip, and shoulder is not known but may be expected to be more variable than when the Hand Standards are used owing to the number of individual bones at each area.

AGREEMENT AMONG SKELETAL ASSESSMENTS

It is possible that measurements by two standards can differ considerably and still be equally valid. For example, the rate of skeletal growth may differ from the rate of skeletal development. It is also likely that the various skeletal regions may mature according to different biologic time schedules. In addition to differences between growth and development and between one skeletal region and another, there is the probability that these relationships differ for the two sexes, for different levels of skeletal maturity, and for individuals.

Growth versus Development. The differences among ratings of the hand made from the growth standards of Baldwin and Kelly and the development standards of Todd and of Greulich and Pyle are given in Table III. The measurements of Dr. Francis have been averaged with those of Dr. Todd for comparison with ratings from other standards because of the extent of disagreement among investigators, and at the suggestion of Dr. Todd, given in personal correspondence: "Please note that the average evaluation of two people over six roentgenograms is not likely to lead the investigator far wrong on the subject of progressive maturation. It is also evident, however, that reliance upon a single roentgenogram and still more on the reading of a single roentgenogram by a single observer is fraught with uncertainty. Even a single

TABLE III

AGREEMENT* OF ASSESSMENTS OF SKELETAL GROWTH AND DEVELOPMENT OF THE HAND

Standards	Frequency of Differences of					Mean Difference
	Greater than −10 mo.	−10 through −4 mo.	−3 through +3 mo.	+4 through +10 mo.	Greater than +10 mo.	mo.
Baldwin-Kelly	1	10	13	7	7	2.6
Baldwin-Todd	3	17	11	12	11	1.4
Baldwin-Greulich, i.†	3	9	20	18	23	6.2
Baldwin-Greulich, m.	1	9	21	21	21	6.3
Kelly-Todd	1	4	5	7	6	3.9
Kelly-Greulich, i.	4	5	6	13	11	4.9
Kelly-Greulich, m.	2	5	7	25	10	5.2
Todd-Greulich, i.		3	32	14	4	3.0
Todd-Greulich, m.		6	26	18	3	3.0
Greulich, i.—Greulich, m.		1	71	3		0.04

* Assessment made by the first standard minus the assessment made by the second.

† Greulich refers to the Greulich-Pyle Standard. The "i" indicates that the inspectional average was applied and "m" the arithmetic mean.

roentgenogram assessed by two observers is, however, fairly reliable."

The disagreement among independent skeletal assessments of the hand is considerable when different standards are applied. Although some standards give an average reading greater than others by as much as six months, the individual differences do not consistently range above or below zero. As the differences are so much greater than those observed between duplicate assessments or between ratings of different observers, it is unlikely that they are due entirely to chance. Other factors affecting these differences will be discussed later. In order to conserve space in the table, the differences are combined into seven-month intervals; the averages, however, are calculated from the differences in months. The distribution of the differences between the two averages based on the Greulich-Pyle Standard (inspectional minus arithmetic mean) has a maximum value of five months compared to twice as great a difference among standards (Table III). This distribution represents differences between methods of obtaining an over-all average for the hand from its individual bones by means of a specific standard. The discrepancy indicates that a greater difference is observed when standards are compared than when the methods of obtaining over-all averages are compared. The average differences for some pairs of standards, such as the Baldwin versus the Todd, are small, although on inspecting the distribution one is impressed by the number of differences that exceed ten months. With the one exception, the growth assessments and the development assessments deviate less among themselves on an average than when they are compared with each other. Such distributions stress the importance of a knowledge of the variability in assessments, especially in the study of individuals.

Skeletal Regions. The differences among assessments made for six skeletal regions are given in Table IV. The assessments for each skeletal area are averages of the readings by Drs. Todd and Francis. The standards for the six skeletal areas were set up for the same group of individuals, and as would be expected the group means for the centers agreed. All the skeletal areas of

TABLE IV

AGREEMENT* OF ASSESSMENTS OF DEVELOPMENT FOR SIX SKELETAL REGIONS

Skeletal Regions	Frequency of Differences of					Mean Difference
	Greater than −10 mo.	−10 through −4 mo.	−3 through +3 mo.	+4 through +10 mo.	Greater than +10 mo.	mo.
Hand-Foot		11	27	22		0.9
Hand-Elbow	2	8	44	24		1.1
Hand-Knee		15	32	9	4	0.2
Hand-Hip	5	9	38	8		−1.3
Hand-Shoulder	1	11	22	20	6	1.9
Foot-Elbow		9	41	10		0.4
Foot-Knee	4	9	34	13		−0.7
Foot-Hip	3	21	27	9		−2.2
Foot-Shoulder		12	27	17	4	1.0
Elbow-Knee	1	17	30	12		−1.2
Elbow-Hip	4	18	31	7		−2.7
Elbow-Shoulder		12	32	16		0.5
Knee-Hip	1	21	28	10		−1.5
Knee-Shoulder		4	39	15	2	1.7
Hip-Shoulder		4	34	17	5	3.2

*Assessment of skeletal development of the first region minus that of the second.

any one individual, however, did not progress at a consistent rate as shown by the range of values.

The differences among the assessments of six regions appear to be as great as those among the assessments of the growth and development of the hand, judging by the spread of individual values (Table III and IV). The mean values, however, indicate that on a group basis there is better agreement among the skeletal areas than among the growth and development measurements of the hand. The extent of the spread of values suggests that factors other than chance and the reliability of the standards of reference are involved.

Skeletal Age. The precision of the duplicate assessments of skeletal development and the agreement of investigators applying the same standard of reference suggests that the lack of agreement in ratings of growth and development of the hand and the development of the skeletal regions are due to factors other than chance. One of the possible factors to be investigated is skeletal age. There might be better agreement among the assessments of growth and development of the hand and among the

TABLE V

AGREEMENT* OF THE BALDWIN AND TODD SKELETAL ASSESSMENTS (HAND) BY SKELETAL AGE PERIODS

Baldwin versus Todd Assessments mo.	Frequency of Differences by Skeletal Age Periods (Todd's Assessments)											
	40–49 mo.	50–59 mo.	60–69 mo.	70–79 mo.	80–89 mo.	90–99 mo.	100–109 mo.	110–119 mo.	120–129 mo.	130–139 mo.	140–149 mo.	150–159 mo.
18		1										
16	1	1	1									
15					1							
14	1											
13		1										
12			1	1								
11	1		1									
9					2	1						
7		1				2						
6		1		1	1	1						
5					1							
4						1						
3					1	1						
2			1		1							
1					1							
0					2							
− 1				1								
− 2				1	1							
− 3		1										
− 4					1				1			
− 5					2							
− 6			1	1								
− 7			1	1		1			1			
− 8	1			1	1							
− 9	1								1			
−10					1				1			
−12				1		1						
−19												1

* The Todd assessments used are average values of the assessments made by Drs. Todd and Francis The differences are the assessments by the Baldwin Standard minus the assessments by the Todd Standard.

ratings of the development of the six skeletal areas if skeletal age were controlled. Table v demonstrates the influence of skeletal age on the agreement of the skeletal assessments of the growth of the hand by the Baldwin Standard and of the development of the hand by the Todd Standard.

There is no apparent trend with skeletal age alone between forty and one hundred months in the difference between the Baldwin and Todd (hand) assessments. The spread for any one skeletal age level is as great as for the total group. If a relationship exists, it is obscured by other factors. There are too few assessments above one hundred months to warrant an evaluation for the group. This is only one of the numerous differences that has been studied, but the same type of scatter diagram was observed for the other relationships between standards for the same or different skeletal area.

Individual Children. Table VI presents the differences among children's skeletal

TABLE VI

AGREEMENT* OF THE BALDWIN AND TODD SKELETAL ASSESSMENTS (HAND) FOR INDIVIDUAL CHILDREN

Baldwin versus Todd Assessments	Boys†											Girls						
mo.	Jimmy	Bobby	Robert	Frank	Maynard	Paul	Donald	Herbert	Norman	Billy	Calvin	Charldine	Josephine	Shirley	Phyllis	Betty	Barbara	Jean
18												1						
16	1	1										1						
15													1					
14	1																	
13	1																	
12		1	1															
11	1	1																
9				2									1					
7			1	1	1													
6				1		1	1							1				
5															1			
4															1			
3														1	1			
2					1		1											
1							1											
0															1	1		
− 1																	1	
− 2								1								1		
− 3									1									
− 4							1									1		
− 5								2										
− 6																1	1	
− 7							1			1							1	1
− 8					1			1										1
− 9					1		1											
−10							1											1
−12										1								1
−19											1							

* The Todd assessments used are average values of the assessments made by Drs. Todd and Francis. The differences are the assessments by the Baldwin Standard minus the assessments by the Todd Standard.

† Siblings are as follows: Jimmy and Herbert are brothers, Norman and Calvin are brothers, Charldine and Josephine are sisters, Robert and Shirley are brother and sister.

assessments (hand) based on the Baldwin versus the Todd Standard. Considerable differences in children can be observed. For example, differences in ratings on Jimmy's four films ranged from eleven to sixteen months, a spread of only five months, with the assessments from the Baldwin Standard always greater than from the Todd Atlas. The four assessments from the Todd Atlas for his brother Herbert ranged from two to eight months, a spread of six months above the corresponding ratings from the Baldwin Standard. This would indicate that Jimmy's bones were growing more rapidly than they were maturing, whereas the reverse was true for Herbert. With the exception of the two children who were studied for the greatest interval of time, Maynard and Donald, the spread or range of differences for an individual represented not more than six months. Apparently the factors of age and stage of growth cannot be ruled out entirely, as the spread of sixteen months between the two assessments for Donald, studied over a seventy-eight month period, indicates changes occurring in his type of skeletal maturation.

Similar distributions were obtained when comparing other measurements of growth and development of the hand. Greater spreads were observed for most of the growth versus development measurements than between assessments of growth or of development. As a general rule the spreads were greatest for children observed over the greater intervals of time.

Distributions were also obtained for comparing assessments of development of six skeletal regions. Better agreement among ratings for the skeletal regions was observed than among ratings of the hand. Age was apparently not an important factor, as the spreads, when one skeletal region was compared with another, were not greater for children studied over the greatest interval of time.

It is also possible that the differences apparently due to age, when a standard of size is being compared with a standard of development, is not a real difference but a result of a basic flaw in the technique. As a child matures the carpal bones intertwine and it becomes increasingly difficult to measure either carpal area or diameter accurately. Although this difficulty is also encountered by those observing maturity indicators, it does not influence qualitative assessments as much as it does quantitative assessments.

In some cases (for example, Jimmy and Herbert) siblings differed as much as nonsiblings, indicating no similarity at the ages under observation; but this observation does not preclude similarities at the same age or stage of development.

The range of differences was similar for the two sexes. It is not to be inferred that skeletal growth is the same for the two sexes but rather that the differences between the standards as developed independently for each sex are similar.

The differences in children are further illustrated by their individual curves measured in terms of maturation in skeletal size or development. Actual assessments made by each scientist are given in the charts rather than averages so that maturation could be observed over as long a period as possible. The skeletal maturation assessments of Donald's hand are given in Figure 1. There is good agreement among maturation estimates from all the hand standards up to ten years of age, but wide discrepancies in maturation estimates occur thereafter, with those from standards of size continuing at approximately the same rate of gain as before, whereas those from standards of development start to decelerate. In contrast, Figure 2 portrays a consistent differentiation for Jimmy between maturation assessments of bone size and of development, each retaining a nearly constant rate of progress at distinct levels from fifty to one hundred and forty months.

The two figures demonstrate that maturation estimates of bone size and of bone development for individuals do vary. The ratings for Donald show good agreement up to ten years of age, but there is a decided difference in the assessments for Jimmy.

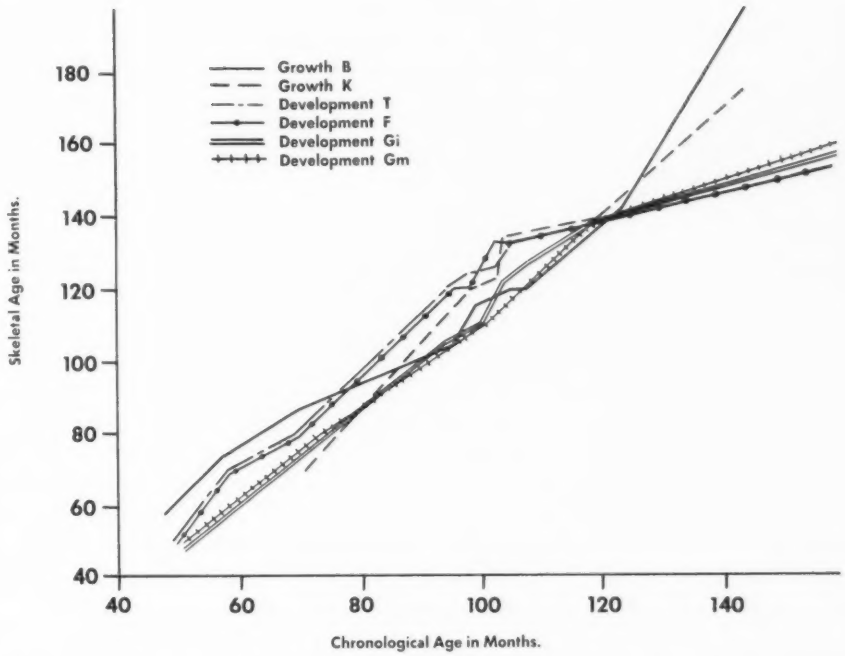

Fig. 1. Growth and development of the bones of Donald's hand. The assessments were made from the Growth Standards of Baldwin (B) and of Kelly (K), and from the Development Standards of Todd as read by Todd (T) and Francis (F) and of Greulich-Pyle by the Inspectional Method (Gi) and the Arithmetic Mean Method (Gm).

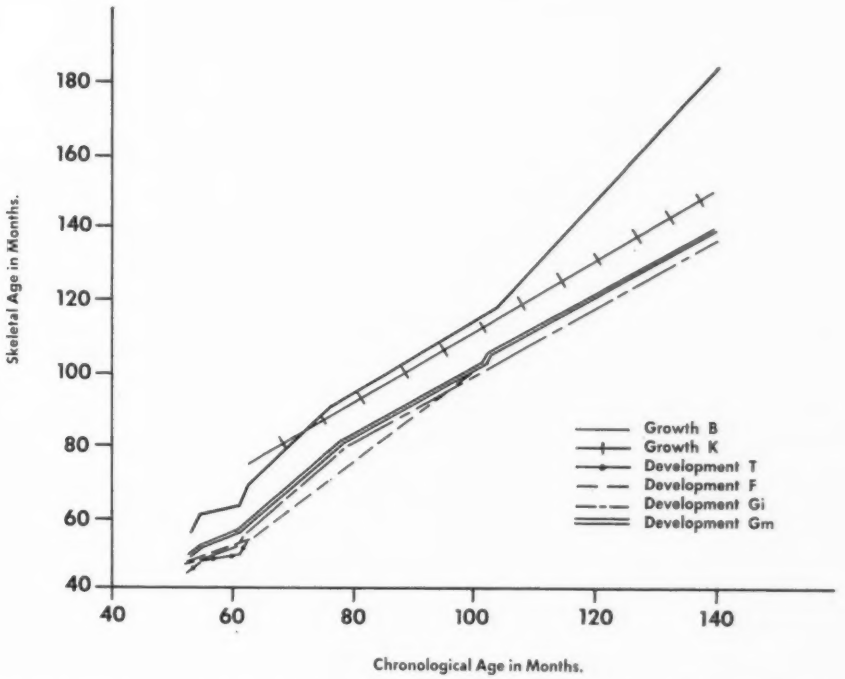

Fig. 2. Growth and development of the bones of Jimmy's hand. The assessments were made from the Growth Standards of Baldwin (B) and of Kelly (K), and from the Development Standards of Todd as read by Todd (T) and Francis (F) and of Greulich-Pyle by the Inspectional Method (Gi) and the Arithmetic Mean Method (Gm).

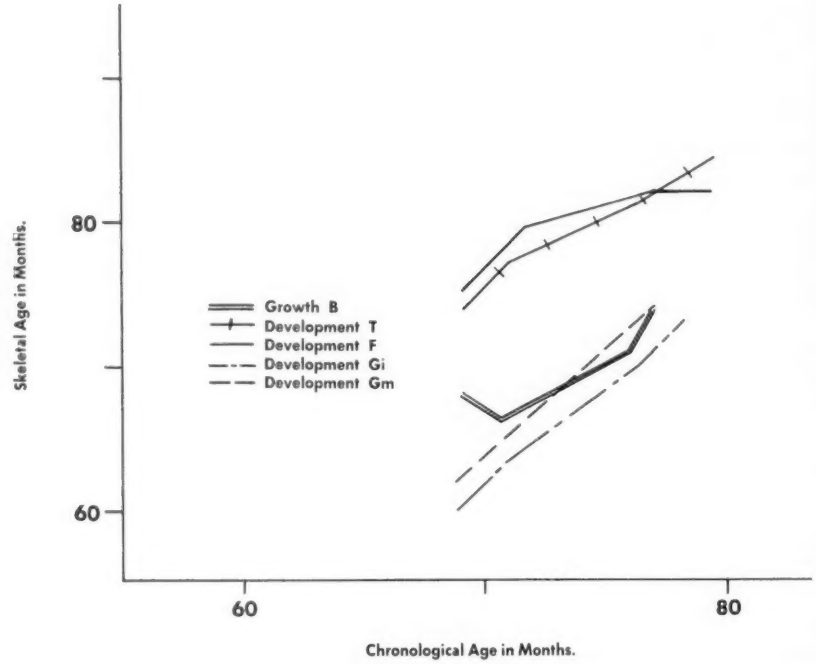

FIG. 3. Growth and development of the bones of Jean's hand. The assessments were made from the Growth Standards of Baldwin (B) and from the Growth Standards of Todd as read by Todd (T) and Francis (F) and of Greulich-Pyle by the Inspectional Method (Gi) and the Arithmetic Mean Method (Gm).

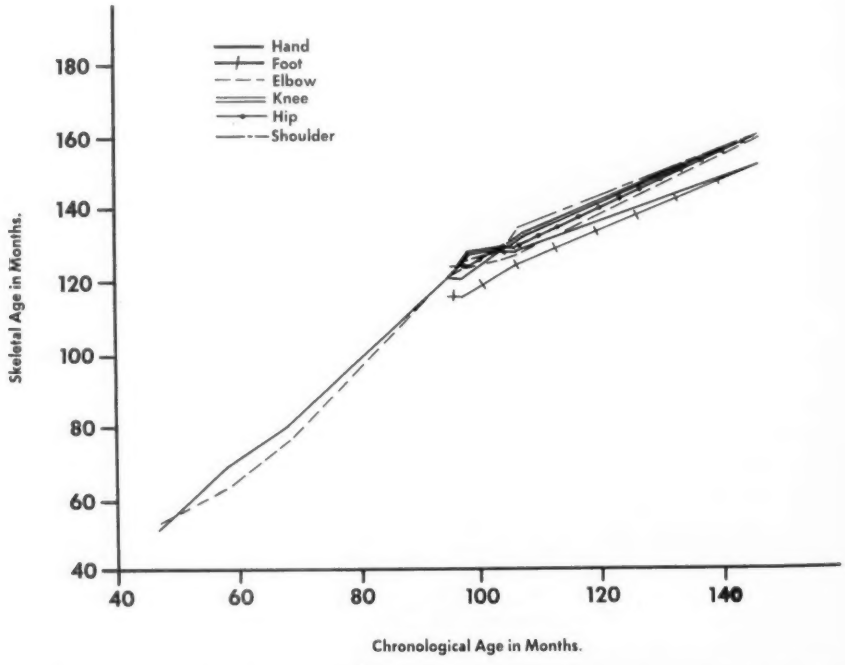

FIG. 4. Development of the bones of Donald's hand, foot, elbow, knee, hip, and shoulder as assessed by Dr. Francis using the Todd Standards.

The shift in growth rate of the curves based on standards of bone development for Donald may be a result of his advanced (zero to fifty-six months) skeletal age level. As he approached skeletal maturity, as judged by the standards, he would necessarily decelerate to approach the terminal stages given in the standards. On the other hand the curves for Jimmy indicate nearly normal development, and therefore it was unlikely that he would pass through a deceleration phase.

Other charts present different relationships between maturation trends as obtained from the hand standards. The curves for Jean (Fig. 3) from sixty-nine to seventy-nine months of age, differed by eight to twelve months based on growth estimates from Baldwin's Standard of bone size and the Todd Standard of bone development. There was excellent agreement, zero to six months, between the maturation estimates from the Baldwin Standards of bone size and the Greulich-Pyle Standards of bone development. The differences between the Todd and Greulich-Pyle assessments result from the change in standards and not from the method of obtaining an over-all average. There is close agreement between the Greulich-Pyle assessments by the inspectional method and the arithmetic mean method.

Figure 4 is a typical illustration of symmetry and agreement among maturation estimates for an individual when the development of one skeletal area is compared with another area.

SUMMARY

The roentgenograms of 17 boys and 10 girls, ages three to fifteen years, were assessed for skeletal growth by the hand standards of Baldwin and Kelly and for skeletal development by the hand standards of Todd and of Greulich and Pyle and Todd standards for the elbow, knee, foot, hip, and shoulder.

The reliability of these standards as applied by experienced scientists was determined by the agreement between duplicate ratings of development of the hand made by one investigator and also by the agreement of assessments of the hand, elbow, knee, foot, hip, and shoulder made by two investigators. The duplicate measurements agreed within four months, whereas the ratings of the two independent investigators agreed within ten months.

Skeletal growth and skeletal development may progress independently according to separate biologic time schedules. There was less agreement between the two maturation ratings of the hand (growth versus development) than among the development ratings of six skeletal regions (hand, elbow, foot, knee, hip, and shoulder). Furthermore, the differences among the assessments of the skeletal regions varied more than the independent assessments of experienced investigators using the same standard.

Individual children under twelve years of age retained characteristic patterns of skeletal maturation. For some children, patterns of growth and development were similar; for others, however, the patterns of growth and development differed.

The results of this study indicate that for skeletal maturation studies of individual children: (1) it is advantageous to have the same assessors make all the readings throughout the maturation period; (2) assessments of growth and development cannot be substituted for one another, but each may contribute descriptive information for a broader characterization of the individual child.

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Vol. 80, No. 3

JUVENILE UNICAMERAL BONE CYST*

A ROENTGEN REAPPRAISAL

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THE application of systematic roentgen analysis to large numbers of bone neoplasms has brought to light extremely interesting and valuable information concerning the relationship of roentgen patterns to tumor behavior and host response. The manner in which the aggressive tumor destroys bone, forms matrix, and incites reactive host response is sufficiently different from the behavior of the slowly growing tumor that, through study of such data, it is now possible from roentgenograms not only to accurately determine the proper classification of a tumor, but also to predict its behavior.[11]

When these new principles of roentgen interpretation are applied to non-neoplastic lesions of the skeletal system, the result is a much sharper and clearer picture of the nature of these lesions than has hitherto been possible to obtain. This paper presents a reappraisal of juvenile unicameral bone cyst in the light of these newer concepts, based upon the author's experience with this lesion and a review of the literature.

CLINICAL EVALUATION

The juvenile unicameral bone cyst comprises but a tiny fraction of a host of roentgenographically cystic appearing lesions, practically all of which are tissue filled lesions surrounded by sclerotic bone. By contrast, the unicameral cyst is fluid-filled and a true cyst. It arises principally in the metaphyses of tubular bones juxtaposed to the epiphyseal plate. It has its greatest frequency at the age of ten, the curve tapering to a very low frequency in the third decade.[1] The average age of the patient with bone cyst is fifteen years. The frequency ratio in boys to girls is 3 to 1.[12]

The unicameral bone cyst is observed principally in the proximal ends of the humerus and femur (Fig. 1). The site next in frequency is the distal end of the femur. Fully 75 per cent of all cysts arise in one of these two bones.[4] An additional 13 per cent are found in the tibia, the frequency in the proximal and distal ends of this bone being equal. The remaining 13 per cent are found in other long bones, the os calcis, and the ilium or ribs.

This frequency distribution is different from the average primary bone tumor, which has its greatest frequency in the distal end of the femur, the proximal end of the tibia, and the proximal end of the

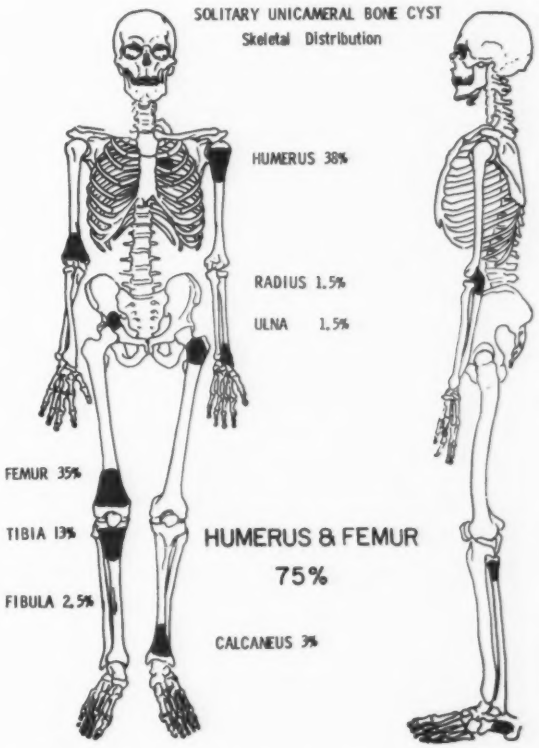

FIG. 1. Skeletal distribution of unicameral bone cyst.

* Presented at the Fifty-eighth Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 1–4, 1957.

humerus. The age, sex, and skeletal distributions of unicameral bone cyst are more like those of epiphyseal chondroblastoma.

The unicameral bone cyst is usually in an advanced stage when first discovered. Its presence may be announced by a vague discomfort, but in most instances it is trauma that calls attention to the lesion. Fifty per cent of new cases have had a pathologic fracture (Fig. 2).[12] Experience with relating location to size in large numbers of bone neoplasms indicates that a centrally located tumor achieves an appreciably larger size than an eccentrically located tumor before causing the symptoms of pain, swelling, or pathologic fracture. This has been interpreted to mean that cortical penetration and periosteal involvement occur earlier in the eccentrically located tumor, and that the involvement of the periosteum secondary to active tumor growth is probably responsible for the earliest painful symptoms in bone tumors. These interpretations applied to juvenile unicameral bone cyst, suggest that the central location, the invariably thin shell of cortical bone between the periosteum and the cyst cavity, and the absence of active invasion account for the generally advanced stage of the lesion and paucity of clinical symptoms. If the cyst is fractured, the break usually heals very rapidly, and rarely, the cyst will spontaneously disappear.

FIG. 2. Early unicameral bone cyst with pathologic fracture. Note that the diameter of the cyst does not exceed that of the epiphyseal plate.

ROENTGEN EVALUATION

The roentgen features of juvenile unicameral bone cyst are classified here in three categories based on: (A) location and size; (B) bone destruction; and (C) bone proliferation.

A. Location and Size. The exact location of cystic lesions of bone is of paramount importance in diagnosis and differential diagnosis, since location may be the sole feature which differentiates between lesions that otherwise are identical. The unicameral bone cyst is found in the metaphysis of the long bone lying juxtaposed to the epiphyseal plate. It extends into the shaft and is greater in length than in breadth. Almost never does it penetrate the epiphyseal plate, although one atypical eccentrically located cyst reported by Hutter[7] was observed to enter the epiphysis. In this instance there was no subsequent arrest of growth at the epiphyseal line.

The location of unicameral bone cyst is central, or rarely eccentric, in the metaphysis. The cyst is elongated in the direction of the shaft, and the transverse diameter at the plate is of the same width as the epiphysis. From the origin of the cyst at the plate, both walls taper gradually to the termination of the cyst at the shaft, enclosing a cystic cavity which has the shape of a truncated cone (Fig. 3). The transverse diameter of the cyst almost never exceeds that of the epiphyseal plate.

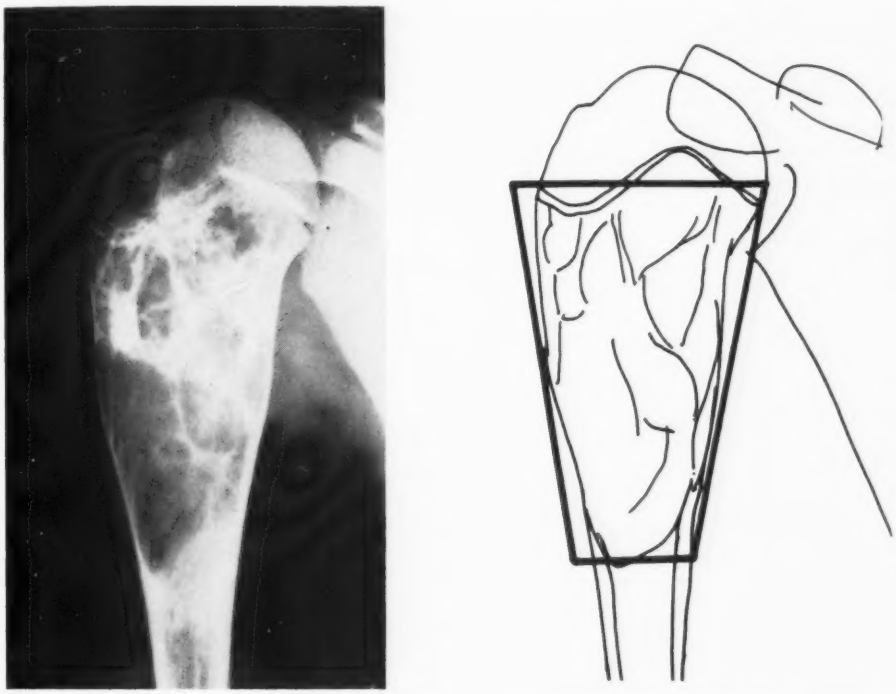

Fig. 3. Juvenile unicameral cyst. Typical shape of truncated cone with base at epiphyseal plate.

It appears that the gradual increase in diameter toward the plate is the result of progressive transverse growth of the plate from which the cyst originates. The diameter of the cyst and the configuration of its wall represent a static retention of the transverse dimension that the cystic cavity attained at the time of its shaftwise growth from the epiphyseal plate, and this elongated wedge shape contrasts sharply with the round or oval shape of most central cystic lesions of bone which result from tumor growth. In such tumors and in the aneurysmal bone cyst, the diameter and configuration of the lesion are entirely unrelated to the diameter of the plate, but are the result of growth in all directions from the center of the tumor, with dynamic expansion of the cortex beyond the normal contour of the bone (Fig. 4).

Eventually as the bone grows, the relationship between the end of the cyst and the epiphyseal plate is terminated, and normal cancellous bone grows between the epiphyseal plate and the cyst wall. With this, the epiphyseal plate gradually grows away from the cyst, which eventually comes to lie within the shaft. This apparent shaftward progression of the cyst is a passive event, and occurs at the normal rate of bone growth. In one recorded instance the cyst migrated from the proximal epiphyseal plate to the mid-shaft of the humerus during a period of nine years.[5]

Jaffe and Lichtenstein[8] have attached special meaning to separation of the cyst wall from the plate, designating those cysts yet in contact with the epiphyseal plate "active," and those migrating toward the shaft "latent." It is their belief that a cyst displaced from the epiphyseal plate is no longer active in its growth potential, and readily amenable to treatment. This is usually but not always true.[9]

It is of great importance to note that the unicameral bone cyst never extends through the cortex into soft tissues. This point alone differentiates the cyst from most bone tumors.

B. Bone Destruction. The pattern of bone destruction of the unicameral bone cyst is of the same unicentric type seen in

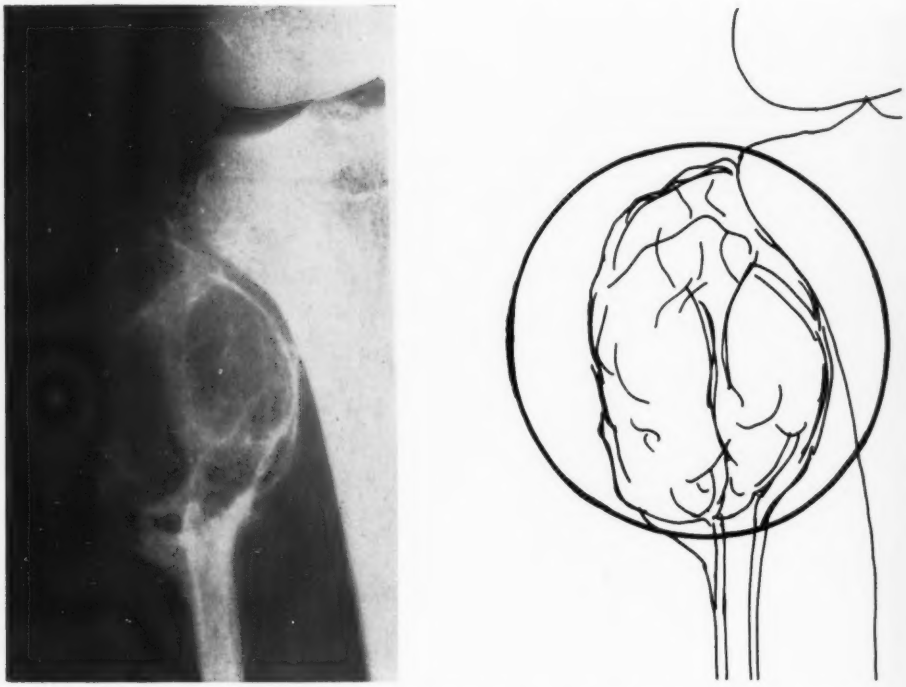

FIG. 4. Giant cell tumor. Typical rounded shape and actively expanded cortex.

the slowly growing benign cystic bone tumor. There is complete destruction of the central spongy bone in the region of the cyst. Since the cyst is usually quite large at the time of its detection, we rarely (if ever) have the opportunity of observing the unicameral cyst when cancellous bone alone is involved. In the typical cyst the regular inner surface of the cortical bone forms a single unilocular cyst with sharply defined edges. The cortex is paper thin on most occasions, but never is completely destroyed. While the edge of the cyst is quite sharp at the cortex and epiphyseal plate, near the narrow end the edge may be indistinct. This indistinct zone tends to become more sharply delineated as the cyst is separated from the epiphyseal line.[12] The contour of the edge is regular or slightly scalloped where trabeculae traverse the inner wall of the cortex.

C. Bone Proliferation. The roentgen patterns of proliferative bone in unicameral bone cyst reflect a lesion without marginal aggressiveness and of static nature. Where the cyst abuts cancellous bone, the reactive sclerosis of bone is reflected in a sclerotic margin. This sclerotic rim varies somewhat in thickness depending upon the duration of the cyst. The inner surface of the cortex is often ridged by thickened trabeculae of bone which may cause the cyst to appear multiloculated. The cortex is thin, dense, and continuous, and the outer surface is smooth. Where fractured, there may be some slight outward pointing or bulging of the thin cortical wall. On healing there is a localized thickening of the cortex, and occasionally, the end of the cyst adjacent to the plate fills in with new bone.[8] Normally, there are no surface lamina of periosteal new bone, and evidences of rapid growth and aggressive behavior such as laminated periostosis, Codman's triangle, and spiculation are uniformly absent.

In summary the roentgen appearance of the unicameral bone cyst is that of a passively maintained unilocular cyst epitomizing the completely benign lesion of bone. Its shape is that of an elongated truncated cone. The cyst never completely perforates

Fig. 5. Early aneurysmal bone cyst. Later the cortex was entirely destroyed, to reappear in an expanded form upon healing of the cyst. Note periosteal lamination and unsharpness of edge of cyst.

the cortex of periosteum, and there is no evidence of active expansion of cortex. Its maximum diameter is that of the epiphyseal plate. Eventually it may separate from the plate to migrate to a mid-shaft position. Laminated periostosis, Codman's triangle, and spiculation are never present.

DIFFERENTIAL DIAGNOSIS

1. Aneurysmal Bone Cyst. The skeletal distribution is similar to that of unicameral bone cyst, although this lesion has a greater predilection to arise in flat bones, such as the vertebral bodies, the pelvis, and the scapula. Like unicameral bone cyst it is found more frequently in the metaphysis of long bones than in the shaft. Differing from unicameral bone cyst, the aneurysmal bone cyst is frequently located eccentrically rather than centrally, and it may penetrate the cortical shell.

The aneurysmal bone cyst contains soft tissue with intercellular matrix, principally metaplastic cartilage and osteoid. These may calcify to form flecks and spotty areas of increased density, a finding uniformly absent in the unicameral bone cyst.

The aneurysmal bone cyst, like unicameral bone cyst, has a cystic unicentric pattern of bone destruction, but there is evidence of a moderate marginal aggressiveness, shown by smudged or even slightly motheaten margins (Fig. 5).

The cortex is often expanded with trabeculation, but the expansion is active rather than passive, and the cyst is spherical rather than tapering and elongated. Periosteal lamination is not an uncommon

FIG. 6. Large benign cortical defect, indistinguishable from nonosteogenic fibroma.

finding with aneurysmal bone cyst, and Codman's triangle may even be observed. A shaggy subperiosteal proliferation of a type quite foreign to benign unicameral bone cyst is seen in this entity.

To summarize: besides being eccentric rather than central in position, the aneurysmal bone cyst also shows evidence of more aggressive behavior than the unicameral cyst.

2. Benign Cortical Defect. This lesion superficially very closely resembles the juvenile bone cyst (Fig. 6). The principal differences lie in the location and size, the cortical defect almost invariably being eccentrically located in the tapered segment of the end of a long bone, several centimeters from the epiphyseal line. It apparently arises in this location. This lesion is usually quite small and is principally cortical in location, although it may involve medullary spongy bone. It never extends through the cortex into soft tissues, with the possible exception of the periosteal desmoid.[10] The large benign cortical defect may involve the entire medullary canal. In this instance it is extremely difficult to differentiate this lesion from the unicameral bone cyst which has become separated from the epiphyseal plate, or from the nonosteogenic fibroma of Jaffe. The close histologic and behavioral resemblance between the cortical defect and nonosteogenic fibroma makes this differentiation somewhat academic.

The pattern of bone destruction in benign cortical defect is cystic, and there is a well developed marginal sclerosis, with trabeculation and marginal scalloping. There is little evidence of active cortical expansion. The principal differential point for separating the benign cortical defect from the juvenile bone cyst lies in its eccentric location in the shaft remote from the growth plate.

3. Giant Cell Tumor. The giant cell tumor is found with greatest frequency in the distal end of the femur and the proximal end of the tibia, locations relatively uncommon for the unicameral bone cyst. Despite categoric statements in the literature[8] that the giant cell tumor always arises in the epiphysis (in adults this is true), prior to fusion of the epiphyseal line the giant cell tumor arises in the metaphysis and lies juxtaposed to the cartilaginous plate. Like unicameral bone cyst, the giant cell tumor rarely extends through the plate into the epiphysis. The giant cell tumor, however, is frequently eccentric in location, and may penetrate the cortex to invade the soft tissues.

The giant cell tumor rarely if ever demonstrates matrix calcification except in healing or following a fracture. The pattern of bone destruction is cystic, but in giant cell tumor there is frequently evidence of greater marginal aggressiveness, such as the smudged, ragged, or slightly motheaten margin. Not infrequently the cortex is completely destroyed in giant cell tumor.

Marginal sclerosis, cortical expansion and trabeculation are frequently observed in giant cell tumor. Occasionally, there is periosteal lamination with giant cell tumor

and rarely Codman's triangle is observed.

The principal differential points between giant cell tumor and unicameral bone cyst are the eccentric location, the complete penetration of the cortex, and the evidence of active expansion of the cortex in the giant cell tumor.

4. Benign Epiphyseal Chondroblastoma. While the basic slowness of growth of both benign chondroblastoma and unicameral bone cyst are reflected in the same general roentgen appearance, the locations of the two lesions are quite different. The benign chondroblastoma almost invariably lies within the epiphysis, and may extend through the plate into the metaphysis (Fig. 7). Chondroblastoma has also been reported to lie in the metaphysis alone. Such cases are extremely rare and atypical and the 2 reported in the literature[2,6] are eccentric in location. The benign chondroblastoma manifests sufficient growth potential to penetrate the cortex and to invade soft tissues. Not infrequently there is flocculent calcification within the chondroblastoma. The cystic pattern of bone destruction with expansion and trabeculation is often present, but the expansion is active rather than passive. Not infrequently the cortex is completely destroyed. Benign chondroblastoma frequently promotes an extensive proliferative response in the form of buttressing, laminated periostosis, and a very shaggy amorphous type of periostosis.

The differential diagnosis between benign chondroblastoma and unicameral bone cyst may be based principally upon location, the former being primarily epiphyseal and the latter metaphyseal. Benign chondroblastoma manifests a degree of aggressiveness of growth that is usually associated with neoplasm.

5. Chondromyxofibroma. This extremely rare tumor is usually metaphyseal in location, but is eccentrically located and has a moderate degree of active cortical expansion. It closely resembles aneurysmal bone cyst in size, location, and general roentgen appearance. The differential diagnosis is the same as for aneurysmal bone cyst.

6. Fibrous Dysplasia. In this condition there is generally more extensive involvement of bone, not related to the epiphyseal plate. Fibrous dysplasia is usually multilocular with the "soap bubble" roentgen appearance, but cortical expansion is slight. There are rare occasions when it would be impossible to differentiate a unicameral bone cyst from fibrous dysplasia by roentgenograms.

7. Enchondroma. While enchondroma occurs most often near the ends of long bone, it may be located in any part of the long bone including the epiphysis. It is usually confined within the cortical shell, and is most often central in location. Not infrequently the enchondroma is marked by multiple floccules of calcific density. The cystic pattern of bone destruction is often less marked due to less involvement of the inner surface of the cortex. Expansion, where present, is usually minimal except where enchondroma merges with chondro-

FIG. 7. Typical benign epiphyseal chondroblastoma. Note eccentric position, with penetration of epiphyseal plate to involve metaphysis.

sarcoma. Rarely should there be a problem of differentiating enchondroma from unicameral bone cyst.

8. Neurofibroma. The problem of differential diagnosis is essentially the same as with fibrous dysplasia.

DISCUSSION

At least five theories have been developed to explain the origin of unicameral bone cyst. Most may be mentioned only to be discarded. These include cystic softening of central bone tumors, abnormal hyperplasia of osteoclasts in a subcortical location following trauma, faulty calcium metabolism, low grade infection (Phemister), and Pommer's theory of unabsorbed traumatic hematoma. This last theory has been given the greatest credence to date, especially since the encapsulation of hematomata and formation of fluid-filled cysts are well documented in other tissues.

All such theories imply an increased fluid pressure within the bone cyst which produces pressure erosion of the inner surface of the cortex with active expansion of the cortical shell in much the same manner as is observed in bone tumors.

Such expansion does not actually seem to occur in unicameral bone cyst. Rather, the diameter of the cystic cavity appears to be predetermined by the diameter of the epiphyseal plate, and until healing occurs, the presence of fluid in the cyst apparently exerts no more pressure than that required to maintain the *status quo*. On the other hand, the unicameral cyst develops in an area of the metaphysis which is normally the seat of very active osteoclastic activity, both inside of the bone in connection with the extensive reorganization which develops in the newly formed endochondral bone; and outside of the cortex in connection with the remodeling of the "cut back" zone which is required to reduce the diameter of the metaphysis to that of the shaft. Normally, as the osteoclastic remodeling activity proceeds on the outer surface of the cortex, simultaneously new bone is being built up on the inner surface of the cortex, in order to retain structural strength. In the unicameral cyst, this internal recon-

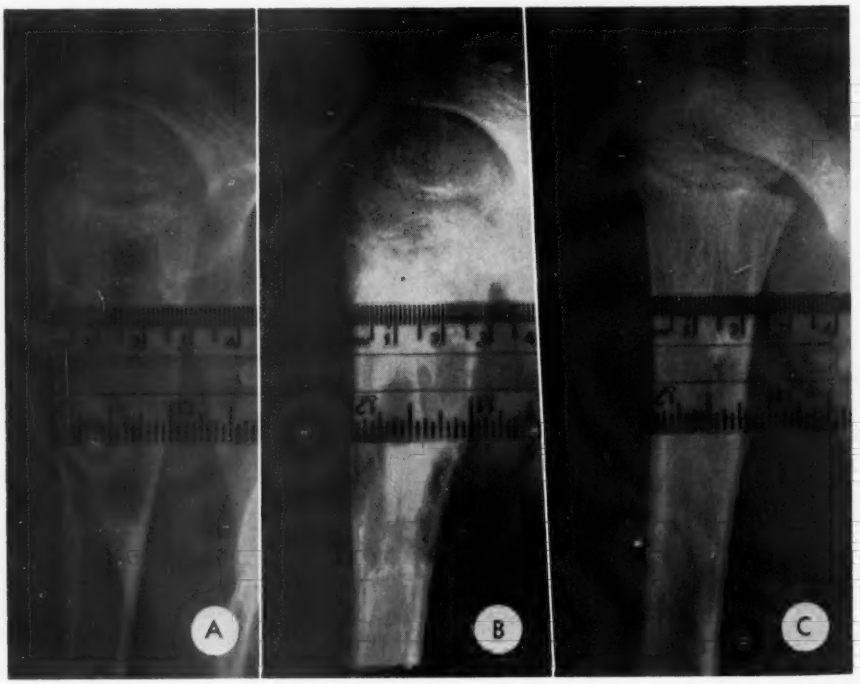

FIG. 8. (*A*) Unicameral bone cyst, male aged seven. (*B*) Same patient two months after curettage of cyst with implantation of bone chips. (*C*) Same patient twenty-six months after treatment. Modeling of the metaphysis has been re-established.

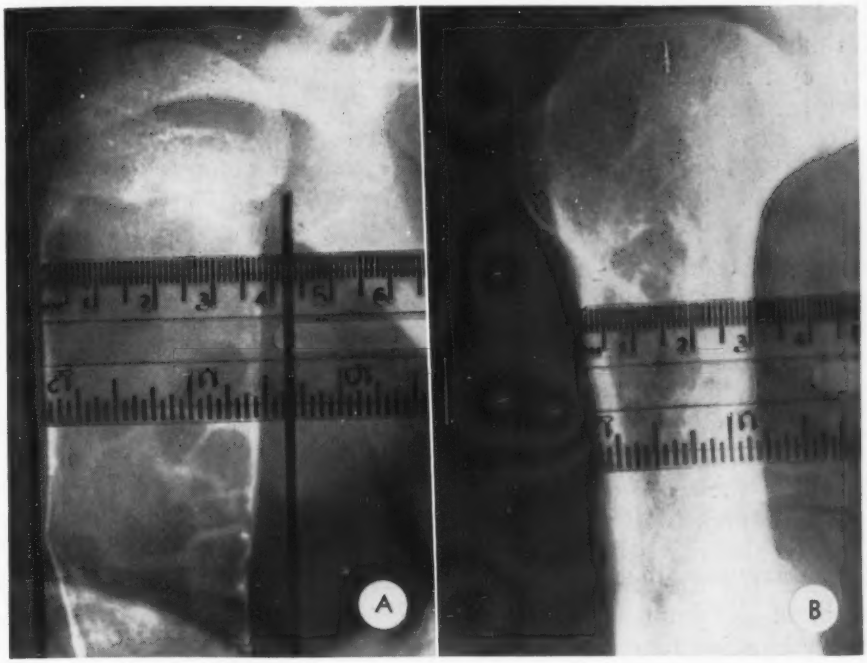

Fig. 9. (*A*) Unicameral bone cyst, female aged ten. (*B*) Same patient fifty-one months after curettage of cyst with implantation of bone chips.

structive process is obviously blocked by the presence of the cyst, while the external remodeling proceeds to the point where the cortex becomes paper thin. Once the epiphyseal plate begins to grow away from the cyst, the normal remodeling process is restored.

It is of great interest and importance to study the healing sequence which follows the successful treatment of unicameral bone cyst. After curettage of the cyst wall and filling of the cavity with bone chips (Fig. 8), healing is heralded by prompt reestablishment of the normal remodeling process so that within a year the diameter and contour of the area previously involved by the cyst may be restored to normal. After several years, reconstruction may be so complete that the earlier presence of a cyst would hardly be suspected (Fig. 9). Such healing may be initiated by curettage alone or even by a simple fracture through the cyst wall. This suggests that simple decompression of the cystic cavity may be an important factor in the promotion of healing.

It seems conclusive that the unicameral bone cyst, arising at the epiphyseal plate, blocks the process of remodeling normally present in the metaphysis. One might further conclude that the mechanism of origin of the unicameral bone cyst might then be some aberration of the normal physiologic reconstruction in the metaphysis. In this zone of intense reconstructive activity on the metaphyseal side of the plate, an area known for conversion defects of cartilage and for neoplasia, it seems possible that a conversion defect of excessive osteoclastic activity could give rise to the cavity of the unicameral cyst. Once initiated, this process is then continuously extended at the epiphyseal plate until operative treatment or natural cause re-establishes internal reconstruction and remodeling.

SUMMARY AND CONCLUSIONS

1. The roentgen appearance of the juvenile unicameral bone cyst epitomizes the static, benign cystic lesion of bone. Its diameter is no greater than that of the epiphyseal plate, and its shape is that of an elongated truncated cone with the base at the epiphyseal plate, in contrast to the

round or oval shape of the bone tumor or aneurysmal bone cyst. These features suggest that the cyst walls are not actively expanded, but rather that they are merely maintained at *status quo*.

2. Differential diagnosis of juvenile unicameral bone cyst from other cystic lesions of bone is based largely upon the absence of actively expanded cortex, the absence of penetration of the cortex, and the juxtaepiphyseal position of the cyst.

3. The presence of the cyst in the metaphysis apparently blocks the normal remodeling mechanism, which is promptly restored when (1) the epiphyseal plate grows away from the cyst; (2) when the cyst is successfully treated. The normal diameter of the bone is eventually restored.

4. It is speculated that the mechanism for the origin of the juvenile unicameral bone cyst may be some temporary aberration of the normal physiology of the region of the epiphyseal plate, such as excessive osteoclastic activity.

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RADIATION THERAPY OF SOLITARY BENIGN CYSTIC-APPEARING LESIONS INVOLVING THE LONG BONES OF CHILDREN*

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ABNORMALITIES of bone, whether due to developmental error, injury or disease are of primary interest to the radiologist mainly from the diagnostic point of view. A certain number of lesions, however, also engender considerable attention as regards the use of radiation therapy as an ancillary, and less frequently, as the most successful method of treatment. Among these latter, the solitary benign cystic-appearing lesions involving the long bones of children occupy a prominent position.

Although the value of such treatment has long been recognized at Harper Hospital,[17,29] only relatively few of the patients afflicted with these lesions are receiving radiation therapy for the following reasons: (1) Benign cystic-appearing lesions are infrequently encountered; (2) benign lesions in children are treated with radiation therapy only when this modality is considered the best approach; (3) reported overtreatment of similar lesions with unsatisfactory results calls for double caution; (4) many of the patients seen have been advised to have treatment by other methods.

CLASSIFICATION

There are several types of solitary benign cystic-appearing lesions involving the long bones in children. Although there still exists considerable confusion as to the pathogenesis or inter-relationship of these conditions, certain aspects have been clarified and a differential diagnosis can be made in most instances. The most common types and the varied terms used for their designation, together with the sites of involvement, are listed in Table I. Terminology most acceptable by virtue of common usage and recognition is indicated at the start of each group, and also in the schematic diagram (Fig. 1) with the most typical location as an aid to differential diagnosis.

The cases presented are of children below the age of twenty years, each of whom had a solitary benign cystic-appearing lesion involving one of the long bones. A summary of the pertinent data is given in Table II.

TREATMENT

Roentgen therapy has comprised the sole treatment or has contributed substantially to a good result. The diagnosis has been arrived at by clinical examination, interpretation of roentgenograms, assay of therapeutic response and re-evaluation of the histopathologic findings, despite the original report. The average tumor dose was 1,182 r delivered in small fractions over a prolonged period with roentgen rays generated at 200 kv. peak potential with 1.5 mm. Cu, 1 mm. Al filtration and a half-value layer of 0.9 mm. Cu at the rate of 13 r per minute. Small fields were used at a target skin distance of 50 cm. Treatment was administered in increments of 200 or less roentgens in air through one or two portals at intervals of one month or longer. The growing metaphysis was carefully protected if possible.

More recently, smaller doses were found to be sufficient so that it is suggested that no more than 1,200 r should be given as a total tumor dose. Usually much less will achieve the desired result. The success of this treatment depends largely upon pa-

*Presented at the Fifty-eighth Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 1–4, 1957.

TABLE I

PRINCIPAL SITES OF INVOLVEMENT AND TERMINOLOGY

I. *Metaphysis*

A. Usually central location

1. Solitary bone cyst
   - Unicameral bone cyst (active phase near epiphysis, Jaffe and Lichtenstein[24])
   - Giant cell variant of bone cyst (near epiphysis and described as acute)
   - Acute bone cyst (Geschickter and Copeland[20])
   - Osteitis fibrosa localisata (Stein, Stein and Beller[41])
   - Local fibrocystic disease
   - Juvenile bone cyst
2. Monostotic fibrous dysplasia
   - Variants (Jaffe and Lichtenstein[25])
     - (a) Osteogenic fibroma
       - ossifying fibroma
       - osteofibroma
       - fibrous osteoma
     - (b) Nonosteogenic fibroma
   - Spindle variant of giant cell tumor
   - Xanthic variant of giant cell tumor
   - Xanthoma
   - Xanthogranuloma

B. Usually eccentric location

1. Aneurysmal bone cyst
   - Subperiosteal giant cell tumor (Coley and Miller[13])
   - Giant cell variant of bone cyst (Geschickter and Copeland[19])
   - Osteitis fibrosa cystica
   - Pulsating giant cell tumor
   - Angioma
   - Ossifying hematoma
2. Cyst of Sontag and Pyle[40] (lower femoral and self-limiting)
3. Very rare chondroma

II. *Diaphysis*

1. Solitary bone cyst (latent phase)
2. Monostotic fibrous dysplasia (not predominant area)
3. Aneurysmal bone cyst (occasional)
4. Chondroma or chondromyxoma (very rare)

III. *Epiphysis*

1. Codman's tumor
   - Epiphyseal chondromatous giant cell tumor (Codman[10])
   - Calcifying giant cell tumor (Ewing)
   - Cartilage-containing giant cell tumor (Kolodny)
   - Benign chondroblastoma of bone (Jaffe and Lichtenstein[26])
   - Chondroblastic tumors, benign and malignant (Geschickter and Copeland[20])
2. Giant cell tumor (typical origin at junction of metaphysis and extends into epiphysis)

tience and careful observation, therefore protraction of the treatment may extend over a year or longer.

MATERIAL

I. METAPHYSIS

The most common of these rare conditions are those that occur in the metaphysis adjacent to the epiphyses. The vast majority are the simple bone cysts or unicameral bone cysts.[24] There has been much discussion as to the pathogenesis of these lesions. The early literature has been extensively reviewed by many authors.[1,12,21,24,35,41] Theories include infection,[7,35,37] trauma or response to hemorrhage into bone marrow, metabolic disorder, localized dystrophy,[21] degeneration of more aggressive tumors, and various manifestations of osteoclastoma.[19,20] Coley[11] believes that none of these theories entirely explains the situation. It is our impression that the response to small amounts of radiation, as will be demonstrated, is more in keeping with the theories of infection than true tumor formation or localized dystrophy. There is general agreement that the condition usually makes its appearance in the metaphysis adjacent to the epiphyses of the long bones of children. Copleman, Vidoli and Crimmings[16] presented 3 cases of their own and 6 collected cases of solitary bone cysts found in the calcaneus. Platt[36] found several instances in the small tubular bones of the hand and foot.

There is no marked sex predominance and the age of onset is between two and eighteen years. The earlier the lesion is discovered the nearer it is to the epiphysis, and with bone growth it progresses down the shaft and becomes more latent in character. There is little symptomatology present and few physical findings are associated with the condition unless a fracture has occurred. Many are discovered accidentally and may have even assumed a latent or mid-shaft position at the initial examination. The fractures themselves heal rapidly and there is seldom displacement. If the development of the cyst is not inter-

TABLE II

Case | Sex Age | Location | Pertinent History | Date of Referral | Roentgen Diagnosis | Pathologic Diagnosis | Tumor Dose in Roentgens | No. Treatments Length Protraction | Length Follow-up | Result

TABLE II

Case	Sex Age (yr.)	Location	Pertinent History	Date of Referral	Roentgen Diagnosis	Pathologic Diagnosis	Tumor Dose in Roentgens	No. Treatments Length Protraction	Length Follow-up	Result
I E.H.	M 4	Metaphysis, left upper humerus	Pathologic fracture through cyst. Referred for therapy since lesion was thought to be too close to epiphysis for surgery, which later proved unnecessary	3/ 6/50	Solitary bone cyst		642	7 fractions 2 yr., 4 mo.	7½ yr.	Excellent, normal use and growth
II M.M.	F 7	Metaphysis, right lower radius	Two fractures 1 month the previous year. Curettement and bone chips 6 months before with absorption; manual fracture 2 months prior to roentgen therapy with continued growth	9/26/52	? Aneurysmal bone cyst	Solitary bone cyst	1,016	8 fractions 6 mo.	5½ yr.	Excellent, normal use and growth
III S.M.	M 3½	Metaphysis, left upper humerus	Pathologic fracture 3 months before. Referred for palliative therapy (child a spastic paraplegic)	8/21/50	Solitary bone cyst	Osteogenic sarcoma and malignant giant cell tumor	718	5 fractions 5 mo.	7 yr.	Excellent, 1 inch shorter than opposite humerus
IV R.S.	F 7	Metaphysis, left upper humerus	Three fractures in previous year. Fusiform enlargement extending into shoulder girdle, painful. After initial therapy amputation recommended elsewhere, but mother refused (patient now married, has 2 children)	8/ 3/32	Solitary bone cyst		1,390	6 fractions 2 yr.	25 yr.	Excellent, normal use and growth
V A.M.	F 5½	Metaphysis, left upper humerus	Injury 6 months previously with swelling of left upper arm. Refracture during treatment healed easily and well	10/ 3/38	Solitary bone cyst	Osteitis fibrosa cystica	879	6 fractions 1 yr., 2 mo.	13 yr.	Excellent, normal use and growth
VI B.W.	F 6½	Metaphysis, right upper femur	Painful limp for 4 months with soft tissue swelling of thigh. Walked, played normally 5 months after first treatment. (Menses at age 15; patient now married and has 1 child)	12/ 6/33	Solitary bone cyst		1,278	6 fractions 5½ mo.	23 yr.	Excellent, normal use and growth
VII M.K.	F 14 mo.	Metaphysis, right upper femur	Pain, swelling and loss of weight-bearing in right leg of one month's duration	3/22/34	Solitary bone cyst		889	6 fractions 4 mo.	23 yr.	Excellent, normal use and growth
VIII R.O.	M 19	Metaphysis, right upper femur	Six months previously dull ache in right thigh. Bed rest 4 weeks. Slight atrophy of thigh. Amputation refused	6/12/30	Aneurysmal bone cyst	Giant cell sarcoma (dark red friable fibrous tissue)	2,528	10 fractions 6 mo.	27 yr.	Excellent, normal use and growth
IX R.S.	M 7	Metaphysis, right upper humerus	Fracture 12 weeks prior to therapy. Second fracture 5 months after institution of therapy. Persistent cyst 6 years after referral	5/ 8/48	Solitary bone cyst	Giant cell tumor	2,243	18 fractions 4 yr., 3 mo.	9 yr.	Excellent, normal use and growth
X B.L.	F 7	Diaphysis, left mid humerus	Fracture through bone cyst 2 years before therapy. Fracture healed in 2 months. Refracture 3 days before referral	7/21/30	Bone cyst ?Monostotic fibrous dysplasia		1,105	7 fractions 7 mo.	27 yr.	Excellent, normal use and growth
XI T.M.	M 11	Diaphysis, right mid tibia	Past 2 years 3 episodes of swelling and tenderness with pain on weight-bearing	11/20/39	Bone cyst ?Monostotic fibrous dysplasia		615	4 fractions 4 mo.	18 yr.	Excellent, normal use
XII E.N.	M 7	Diaphysis, left mid humerus	Fracture 3 months previously. Refractured before referral	6/ 2/29	Monostotic fibrous dysplasia	Osteitis fibrosa cystica	777	3 fractions 4 mo.	28 yr.	Excellent, normal use and growth
XIII D.B.	M 8	Angle left mandible	Painless swelling left jaw. Included for comparison	8/23/40	Monostotic fibrous dysplasia	Giant cell tumor. Fibrous central	864	2 fractions 2 mo.	7 yr.	Excellent, normal use and growth
XIV J.D.	M 3	Diaphysis, left mid femur	Fracture 2 months previously. Curettement, bone chips. Nearly 5 years post-radiation therapy, injury and malignant change with disarticulation	6/ 8/43	Periosteal fibrosarcoma	Benign bone cyst (cartilage present, sections unavailable)	169	2 fractions 2 mo.	14 yr.	Disarticulation for malignancy, patient well
XV E.K.	F 15	Epiphysis, greater trochanter right femur	Pain for 1 year. Limitation in motion for 2 months. Amputation refused (patient now married and has 3 children)	6/ 4/38	Codman's tumor	Ewing's tumor (consultation on slides, chondromatous epiphyseal giant cell tumor)	2,356	4 fractions 11 mo.	29 yr.	Excellent, normal use and function

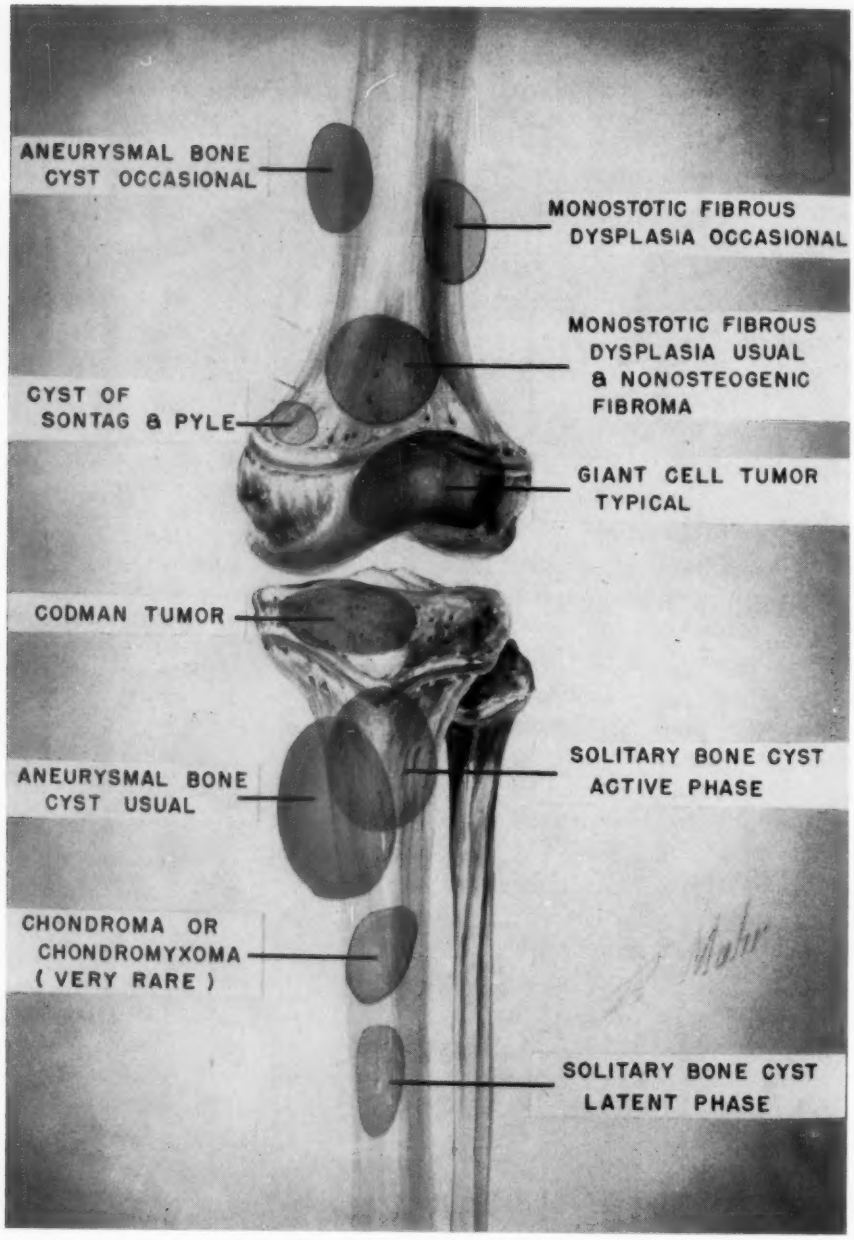
ANEURYSMAL BONE CYST OCCASIONAL
MONOSTOTIC FIBROUS DYSPLASIA OCCASIONAL
MONOSTOTIC FIBROUS DYSPLASIA USUAL & NONOSTEOGENIC FIBROMA
CYST OF SONTAG & PYLE
GIANT CELL TUMOR TYPICAL
CODMAN TUMOR
SOLITARY BONE CYST ACTIVE PHASE
ANEURYSMAL BONE CYST USUAL
CHONDROMA OR CHONDROMYXOMA (VERY RARE)
SOLITARY BONE CYST LATENT PHASE

FIG. 1. Schematic drawing indicating the most typical location of the various cystic-appearing lesions.

rupted, it may come to occupy one-third or one-half of the bone. There may also be bone shortening.

Roentgenographically, the condition is generally typical and manifests itself as an area of central rarefaction with thinning and occasional expansion of the cortex. There are irregular trabeculations scattered about haphazardly. These, on gross pathologic examination, are ridges on the medullary surface of the cortex rather than true septa. In nearly one-half of the lesions at the time of initial examination, a pathologic fracture is found. Monostotic fibrous dysplasia and the extremely rare chondromyxoma appearing in this region are almost impossible to differentiate roentgenographically. (It has been suggested that the chondromyxoma is more finely loculated.[20])

The surgical treatment advocated is

curettement with or without bone graft or bone chips placed in the cavity. Its value has been reviewed by Coley and Higinbotham,[12] Alldredge,[3] and others in more general discussions of the condition. Recurrence following surgery with curettement and bone chips, with or without escharotics, does occur,[41] particularly when the lesion is in the active phase near the epiphysis. For example, Graham,[21] reports 41.9 per cent recurrence in 31 cases. Also, there is a risk of epiphyseal damage from operation in these cases. Another undesirable feature found following surgery in these children is the production of large, and sometimes disfiguring, scars which may have to be removed in later life. Jaffe and Lichtenstein[24] state that it is in the latent phase, after the lesion has progressed away from the epiphysis, that cysts are cured more readily by curettage and filling with autogenous bone chips.

Although there have been cases reported of spontaneous healing following fracture,[1,3,11,34] this is not the usual course and many patients who became asymptomatic have had residual cysts and deformity, and often marked shortening of the bone. Alldredge[3] analyzed 22 cases treated by fracture and immobilization only, and in no case did he find a completely satisfactory result. Geschickter and Copeland[20] state that "in the acute bone cyst or giant cell variant occurring in the metaphyses, roentgen therapy in moderate doses is the treatment of choice—in case of failure with irradiation, operative interference should be employed." Others have held the same view and a few serious attempts at treatment with radiation therapy have been made. LeWald[27] reported 4 cases in children treated with moderate doses of roentgen rays obtained with 120 kv. and 4 mm. Al filtration and given at intervals of one week. These children received excellent results. He stated that "biopsy is not essential as the response to x-ray treatment may be taken as confirmation of the x-ray diagnosis."

There are references to radiation therapy of the simple bone cyst in the literature, but the treatment factors are rarely mentioned. Coley and Higinbotham[12] reported 8 cases treated with irradiation with good results in 5, fair results in 2 and 1 untraced. Geschickter and Copeland,[20] in their series of typical bone cysts, described 16 cases treated primarily by radiation therapy and reported good results. Alldredge,[3] in analyzing the results of treatment in 152 cases, found 6 good results and 6 poor results in those treated by roentgen therapy alone, of which there were 15. No dosage is given. He also reports a case in which improvement followed a poor surgical result after roentgen therapy was administered. Freund and Meffert[18] observed a case treated by radiation therapy in an eleven year old girl who had gradual improvement over a period of one year. Both Alldredge[3] and Coley[11] believe that radiation therapy should be used for inoperable or inaccessible lesions.

In our own experience relatively small doses of carefully applied protracted roentgen therapy produced excellent results with less deformity than could be expected from surgery in the active or acute bone cyst in metaphyseal location.

Case 1 (Fig 2, *A*, *B*, *C* and *D*) is an example of an acute bone cyst of the left upper humerus referred for roentgen therapy because of risk of epiphyseal injury from operation. Following irradiation with a total tumor dose of 642 r, given in 7 fractions over a period of two years and four months, there was good result with normal use of the upper limb seven and one-half years later. Radiation therapy may also be employed after an unsatisfactory surgical result, as illustrated in Case 11 (Fig. 3, *A*, *B*, *C* and *D*). After two unsuccessful attempts at improvement (curettage and insertion of bone chips, and later manual fracture) the lesion of the right distal radius received 1,016 r total tumor dose in 8 fractions over six months, resulting in complete restoration of the normal function of the upper limb five and one-half years later. Because of the destruction of the cortex and rapid cystic growth prior to therapy, one might con-

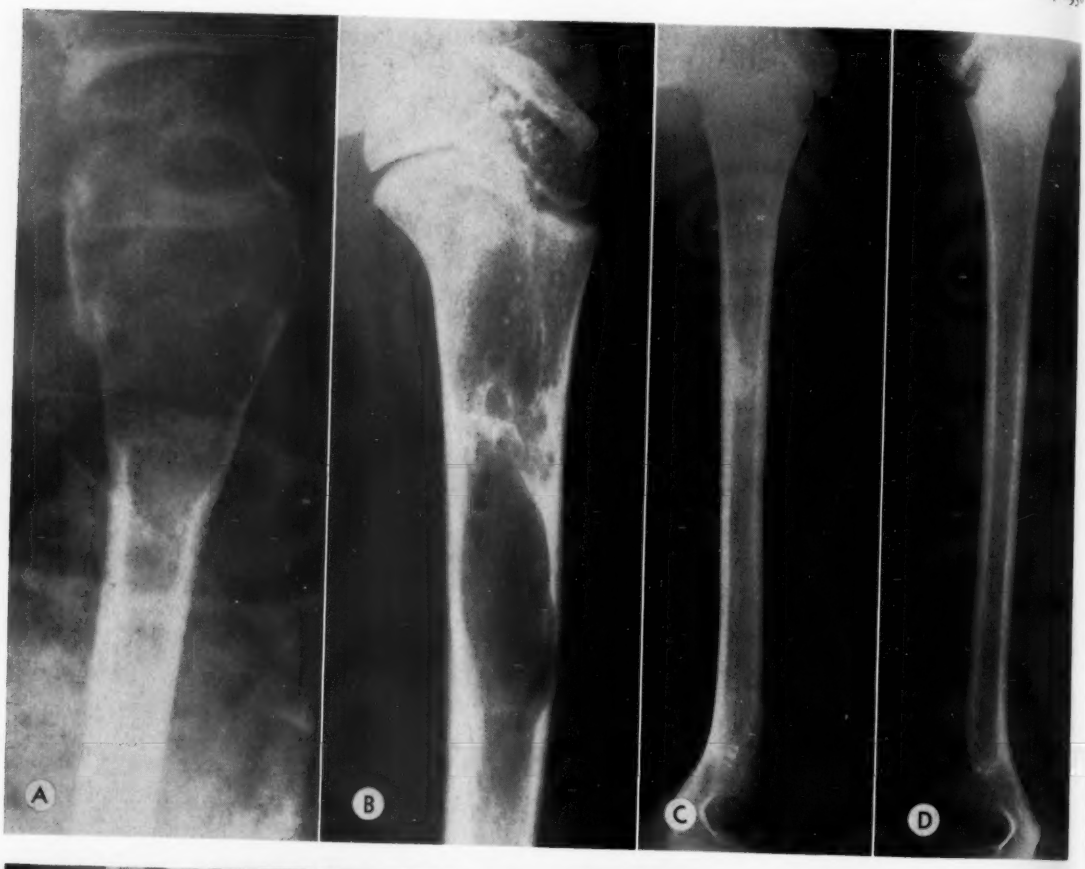
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Fig. 2. Case I. (*A*) March, 1950: Solitary bone cyst of the left upper humerus with pathologic fracture before radiation therapy. (*B*) November, 1952: Appearance following administration of a total tumor dose of 642 r in 7 fractions over a period of two years and four months. (*C* and *D*) February, 1957: Comparison with the opposite humerus (*D*) seven and one-half years later shows no growth disturbance.

sider the possibility of aneurysmal bone cyst despite a biopsy report to the contrary.

Case III (Fig. 4, *A*, *B* and *C*) is that of a child with spastic paraplegia referred for palliative roentgen therapy after a biopsy specimen of a tumor of the left upper humerus was reported as osteogenic sarcoma and a second histopathologic examination as malignant giant cell tumor. A tumor dose of 718 r given in 5 fractions over five months produced good healing, although seven years later there was a one inch shortening of the patient's left arm. Evidently, on the basis of the roentgen appearance and radiation response, the lesion is best classified as belonging in the group of questionable calcifying enchondroma.

Cases IV, V, VI and VII showed excellent results in typically appearing solitary bone cysts, 2 of the left upper humerus and 2 of the right upper femur, twenty-five, thirteen, twenty-three and twenty-three years later. The respective tumor doses were 1,390 r in 6 fractions over two years in Case IV (Fig. 5, *A*, *B* and *C*) 879 r in 6 fractions over one year and two months in Case V (Fig. 6, *A*, *B* and *C*), 1,278 r in 6 fractions over five and one-half months in Case VI (Fig. 7, *A*, *B*, *C* and *D*) and 889 r in 6 fractions over four months in Case VII (Fig. 8, *A*, *B* and *C*). In none of the cases was there, after many years, any perceptible change in the skin, soft tissues or bone growth as a result of the small amount of radiation necessary. In Case IV an amputation was considered originally but this was refused by the patient's mother.

Case VIII (Fig. 9, *A*, *B* and *C*) is not a typical solitary bone cyst of the right upper femur and from the biopsy report may be representative of an aneurysmal bone cyst. A review of the roentgenograms and the response to treatment suggest an enchondromatous giant cell tumor occurring in the metaphysis. A good result was obtained from a tumor dose of 2,528 r given in 10 fractions over six months, and the patient had normal use of the lower extremity twenty-seven years later. In this case, too, amputation suggested as the initial treatment was refused by the parents.

Case IX (Fig. 10, *A*, *B* and *C*) is an instance in which surgical intervention became necessary following roentgen therapy to a solitary bone cyst of the right upper humerus. A tumor dose of 2,243 r was given in 18 fractions over a period of four years and three months. A third fracture occurred following the surgery. Specimens at the time of the original biopsy and at surgery six years later were carefully compared and revealed the same type of tissue. In this persistent cyst, operation was made easier by its increased latency and migration from the epiphysis. In the interval the patient was symptom-free.

The aneurysmal bone cyst recently has been discussed extensively in the literature and reported as a separate entity.[4,6,23,30,31,33,39,42] It has been described under various names as shown in Table I. The presenting symptoms usually are pain, swelling, tenderness and limitation of motion. It may occur in the flat bones and vertebral column as well as in the long

Fig. 3. Case II. (*A*) August, 1951: Cystic lesion (aneurysmal?) of the right lower radius with pathologic fracture. Curettage and insertion of bone chips and later manual fracture remained unsuccessful and the lesion continued to increase in size. (*B*) September, 1952: Appearance before radiation therapy. (*C* and D) February, 1958: After administration of a tumor dose of 1,016 r in 8 fractions over six months, complete healing followed and five and one-half years later comparison with the opposite radius (*D*) reveals no growth disturbance.

FIG. 4. Case III. (*A*) August, 1950: Appearance before radiation therapy. A pathologic fracture of the left upper humerus had occurred three months prior to referral. The first histopathologic report was that of osteogenic sarcoma; the diagnosis was later changed to malignant giant cell tumor. (*B*) August, 1953: After administration of a total tumor dose of 718 r in 5 fractions over a period of five months, there was good progress toward healing. (*C*) September, 1957: Seven years after institution of radiation therapy, there is an excellent functional result, although the left arm is one inch shorter than the opposite arm.

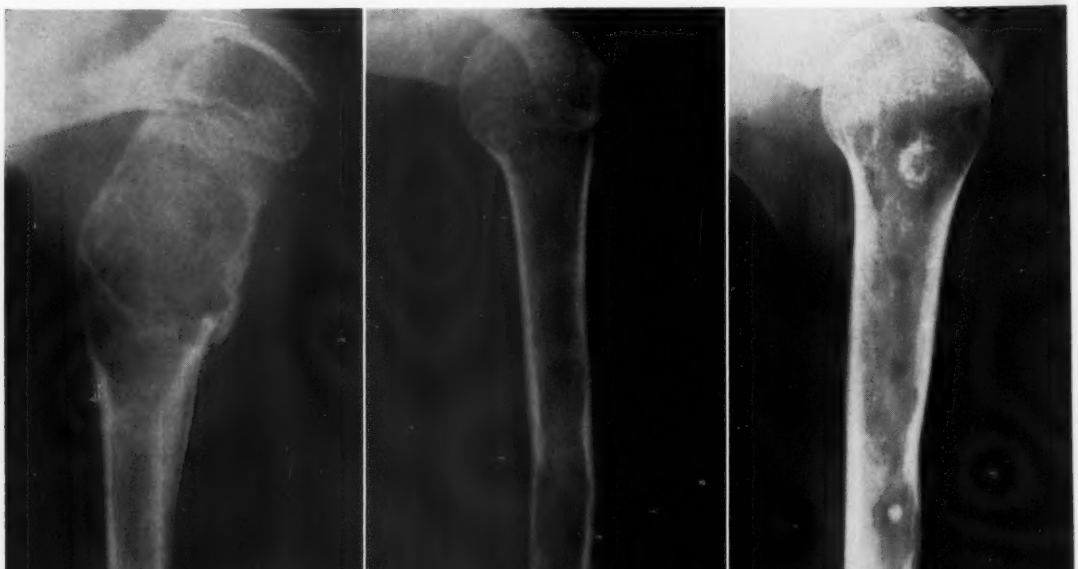

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Fig. 6. Case v. (*A*) October, 1938: Solitary bone cyst of the left upper humerus with pathologic fracture before radiation therapy. The histopathologic report was that of osteitis fibrosa cystica. (*B*) July, 1940: After administration of a total tumor dose of 879 r in 6 fractions over a period of fourteen months, there was good progress toward re-ossification. A second fracture occurred during treatment which healed uneventfully. (*C*) June, 1950: Roentgenogram taken thirteen years after institution of radiation therapy shows good bone growth with only slight curvature of the shaft of the humerus.

bones and is observed most frequently in the second decade of life. The typical lesion is eccentrically placed and roentgenograms show a ballooning-out of a thinned cortex with a radiolucent central portion which is indistinctly mottled and often trabeculated. There are instances in which the tumor is centrally located in a long bone and resembles a unicameral or simple bone cyst. The honey-combing, or trabeculation, has been described as slightly finer than in the bone cyst by Sherman and Soong.[39] The confusion of a unicameral or simple bone cyst with the rare centrally located aneurysmal bone cyst is not too serious from the standpoint of the radiation therapist. Coley and Miller[13] reported as an atypical giant cell tumor a case of a

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Fig. 5. Case iv. (*A*) August, 1932: Solitary bone cyst of the left upper humerus before radiation therapy. The patient suffered 3 fractures the previous year and, therefore, amputation was recommended elsewhere but refused by the patient's mother. (*B*) August, 1940: After administration of a total tumor dose of 1,390 r in 6 fractions over two years, there was good healing and eight years later the site of the lesion was in the mid shaft. (*C*) September, 1949: Roentgenogram taken seventeen years later shows solid bone with normal growth. The patient continues to have excellent function twenty-five years after her first treatment. She married and has two normal children.

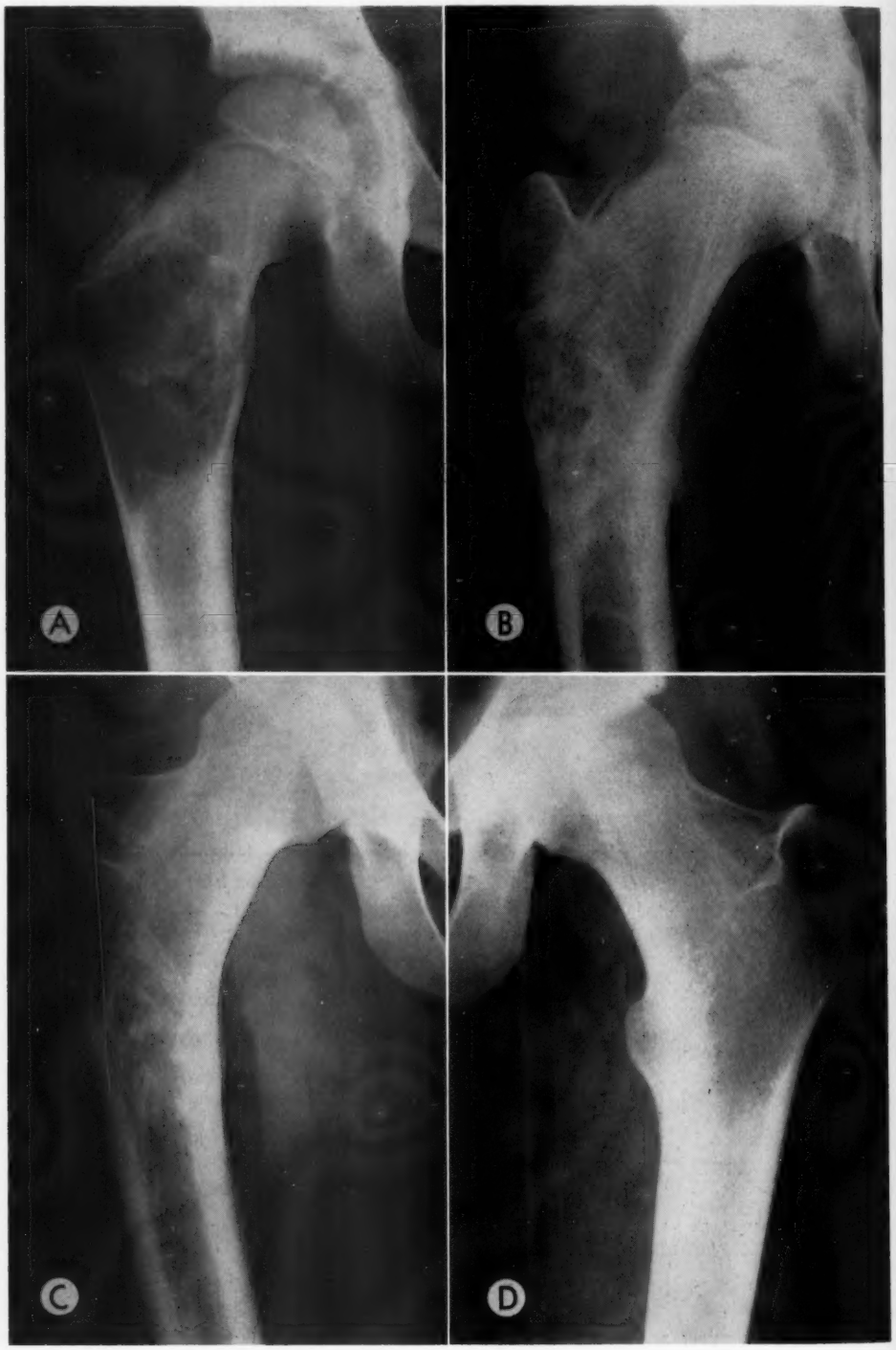

FIG. 7. Case VI. (*A*) January, 1934: Solitary bone cyst of the right upper femur before radiation therapy. (*B*) February, 1940: After administration of a total tumor dose of 1,278 r in 6 fractions over a period of five and one-half months, there was satisfactory improvement and roentgenogram made eight years later showed good re-ossification. (*C* and *D*) February, 1957: Comparison with the opposite femur (*D*) twenty-three years later reveals no growth disturbances. The patient married and has a normal child.

FIG. 8. Case VII. (*A*) March, 1934: Solitary bone cyst of the right upper femur before radiation therapy. (*B* and *C*) March, 1939: After administration of a total tumor dose of 889 r in 6 fractions over a period of four months, there was good healing and comparison with the opposite side (*C*) five years later shows normal bone growth. In 1957, twenty-three years after the initial treatment, the patient had normal use of the leg.

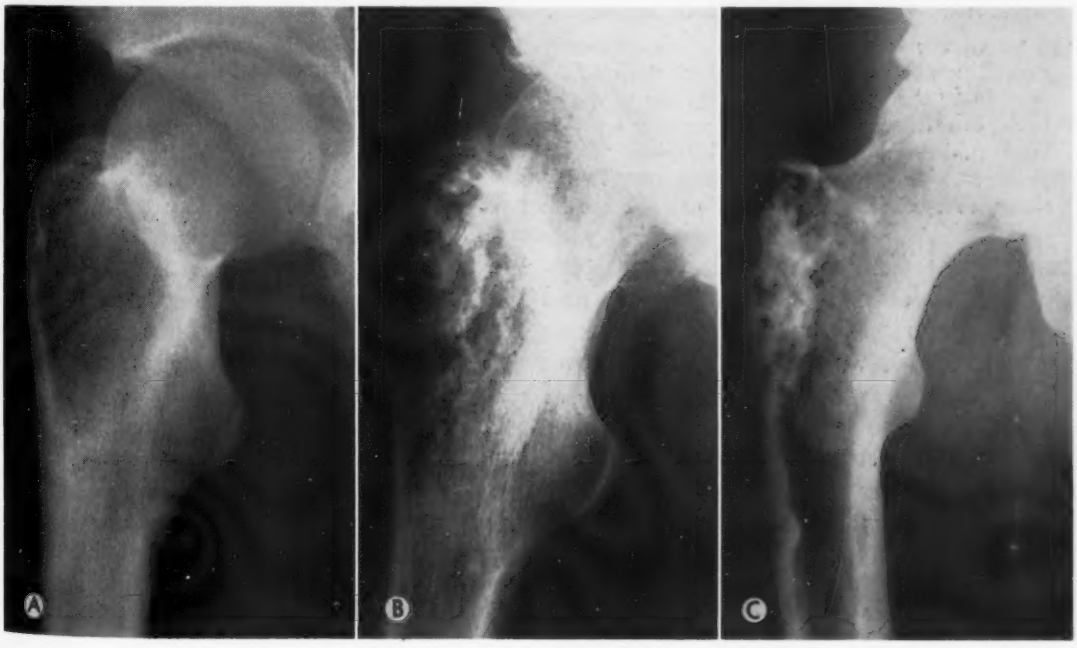

FIG. 9. Case VIII. (*A*) June, 1930: Lesion of the right upper femur before radiation therapy. The histopathologic report was that of aneurysmal bone cyst, but a review of the roentgenograms and the response to treatment suggested an enchondromatous giant cell tumor. Amputation was refused by the parents. (*B*) December, 1930: After administration of a total tumor dose of 2,528 r in 10 fractions over six months, there was satisfactory improvement. (*C*) June, 1957: Roentgenogram made twenty-seven years later shows good re-ossification. There is an excellent functional result.

FIG. 10. Case IX. (*A*) March, 1949: Solitary bone cyst of the right upper humerus ten months after institution of radiation therapy. The initial pathologic fracture has healed and normal bone growth has started to displace the cyst toward the middle of the shaft. (*B*) August, 1954: After administration of a total tumor dose of 2,243 r in 18 fractions over a period of four years and three months, the cyst, which now is in the mid shaft, has not as yet filled in and, therefore, surgery was performed. (*C*) March, 1957: Roentgenogram nine years following institution of radiation therapy and two and one-half years following surgery shows a very satisfactory result. The patient has normal use of the arm.

twelve year old boy treated by roentgen therapy with good result. Sherman and Soong[39] gave 2,000 r tissue dose in two weeks to 8 patients with this condition and obtained good results in 7. Taylor[42] reported 3 cases, 2 of which were treated by irradiation with satisfactory results. Lichtenstein[33] in a recent publication reviewed 50 cases, many treated by radiation therapy with excellent result, and recommended this modality where operation is unfeasible, difficult or incomplete. He stated that 1,400 r tumor dose should suffice for effective control. The only objection that Barnes[4] has to radiation therapy is that no biopsy is obtained.

Herendeen[22] in an early report on treatment of giant cell tumors by roentgen ray, including some of the types of cysts we have discussed, made the observation that when a tumor appears in younger individuals there is a more rapid response to treatment. This also has been our observation and we have noted that in children less total treatment is necessary. So little treatment has been administered, particularly in the first 3 cases presented, that the question arises whether some might not have healed spontaneously. Brunschwig[9] reported several collected cases where cysts had persisted for many years, one for as long as fifty-one years. Graham[21] likewise

reported cases of several years' duration, some of which were recurrences following surgery that were cured by re-operation one to nine years later. There are many cases recorded in the literature which have been followed after fracture and immobilization without proper healing.[3,5,12,21,24]

II. DIAPHYSIS

Within the shaft of the long bones of children one may find such solitary cystic-appearing lesions as latent bone cysts, monostotic fibrous dysplasia, occasionally aneurysmal bone cysts and rarely a centrally located chondroma or chondromyxoma. All of these conditions are benign with only the rare chondroma of proved potential malignancy. It is unusual for the radiologist to be asked to treat such a cystic lesion even though the involved portion of bone is further removed from the epiphysis and the risk of confusion with malignant tumors is less likely. These cystic-appearing lesions are less frequent, less symptomatic and are more easily operated upon. The sole exception may be an aneurysmal bone cyst which may be painful and may produce swelling.[4,6,23,30,31,42] Only when centrally located, will these lesions be confused with other tumors of this group.[31] Aneurysmal bone cyst, when occurring in long bones, is more often located adjacent to the metaphyses and then it is eccentrically placed.

Three cases with cystic-appearing lesions occurring in the diaphysis and treated primarily by roentgen therapy are included in our series. Two of these cases had a biopsy with a suggestion of malignancy in one of them. The clinical and roentgenologic impression was that all were benign. Conservative, spaced roentgen therapy was administered with excellent result obtained in each case. Case x (Fig. 11, *A*, *B*, *C* and *D*) received 1,105 r tumor dose in 7 fractions over seven months to the left mid humerus and has normal use of her affected arm twenty-seven years later. Case xi (Fig. 12, *A* and *B*) was irradiated with 615 r given in 4 fractions over four months for a cyst of the right mid tibia and likewise has normal use of his lower limb eighteen years later. Careful review of all available material suggests that today we would classify these 2 cases as monostotic fibrous dysplasia, originally containing angiomatous, lipomatous or fibrous tissue which later calcified in response to therapy. Case xii (Fig. 13, *A*, *B* and *C*) in retrospect undoubtedly was one of monostotic fibrous dysplasia. This patient was treated with 777 r tumor dose to the left mid humerus in 3 fractions over four months, and obtained an excellent result, there being normal appearance and function of her arm twenty-eight years later.

Schlumberger[38] has described in detail the monostotic type of fibrous dysplasia which may appear in the long bones of children and which assumes a radiolucent cyst-like appearance, sometimes difficult to differentiate from the unicameral bone cyst. It has also been identified in bones of the skull, mandible, ribs, pelvis and vertebrae. This condition apparently is not related to endocrine dysfunction or to Albright's disease.[2] It is one of the less active conditions of those under discussion and may be latent for many years, and if asymptomatic and nonprogressive can be ignored. It is interesting to note that of 69 cases reviewed,[38] there were 21 different diagnoses by radiologists and 14 different diagnoses by pathologists (malignancy was suggested in 3 cases by radiologists and in 5 cases by pathologists). Occasionally, there is local swelling and some type of local tenderness. It has been likened to keloid or callus following injury. The roentgen findings are not characteristic but the lesion is usually centrally located in the metaphyses, slightly away from the epiphyses and sometimes in the mid shaft of the long bones. Radiolucent areas are traversed by delicate trabeculae. There may be thinning and expansion of the cortex, particularly in the ulna and fibula. The osseus fibroma of Lichtenstein[32] and the rare nonosteogenic fibroma described by Jaffe and Lichtenstein[25] are probably variants of the same condition. These tumors are rare and are so benign in their nature that trial

FIG. 11. Case X. (*A*) July, 1930: Bone cyst of the mid shaft of the left humerus with recurrent pathologic fracture before radiation therapy. (*B*) September, 1932: After administration of a total tumor dose of 1,105 r in 7 fractions over a period of seven months, there was good healing. (*C* and *D*) August, 1957: Comparison with the opposite humerus (*D*) twenty-seven years later shows no growth disturbance. Patient has normal use of the arm.

of a small dose of radiation would do them no injury and, if the symptoms persist, they could be operated upon later.

Besides the above mentioned case (Case XII), we have observed several cases of monostotic fibrous dysplasia occurring in the mandible which have been treated in a similar manner. Case XIII (Fig. 14, *A*, *B* and *C*) represents an example of such a lesion. The patient received a tumor dose of

FIG. 12. Case XI. (*A*) November, 1939: Bone cyst of the mid shaft of the right tibia before radiation therapy. (*B*) November, 1942: After the administration of a total tumor dose of 615 r in 4 fractions over a four month period, there was excellent re-ossification. The patient was re-checked in 1957 and was found to have normal use of the leg, eighteen years after institution of therapy.

Fig. 13. Case XII. (*A*) June, 1929: Bone cyst of the mid shaft of the left humerus with recurrent pathologic fracture before radiation therapy. The histopathologic diagnosis was that of osteitis fibrosa cystica. (*B*) October, 1929: After administration of a total tumor dose of 777 r in 3 fractions over four months, there was marked improvement. (*C*) September, 1939: Roentgenogram taken ten years later shows good re-ossification. The patient was seen in 1957, twenty-eight years after initial treatment and was found to have a normal use of the arm.

864 r in 2 treatments over a two month period and at the present, seven years later, shows a normal roentgen appearance of the left mandible.

Case XIV (Fig. 15, *A*, *B* and *C*) may also be included here. On original biopsy a benign bone cyst of the left mid femur was reported, but we noted that cartilage tissue was present. Minimal roentgen therapy was given following curettement and insertion of bone chips in an attempt to produce filling-in of the remaining defect. Four years after initial treatment follow-up examination disclosed malignant change and disarticulation at the hip joint was successful in saving the patient's life. The second histopathologic report was that of periosteal fibrosarcoma.

III. EPIPHYSIS

One of the rarest conditions of the entire series is a cystic-appearing lesion originating in the epiphysis prior to its closure, and sometimes extending into and involving the nearby metaphysis. This, Codman[10] has termed "the epiphyseal chondromatous giant cell tumor," and he reported 9 similar cases from the Bone Sarcoma Registry. It is interesting to note that in one of these cases, a ten year old boy, 8 members of the Registry, after examining all aspects of the case, felt that it was a sarcoma and 6, later 7, diagnosed it a benign giant cell tumor. Three of the cases described by Codman were treated by roentgen therapy.

Since the original study, additional investigations on the nature of the epiphy-

seal lesions have been carried out, notably by Jaffe and Lichtenstein[23,26] who have suggested the term "chondroblastoma," and by Copeland and Geschickter[15,20] who analyzed the relationship of the variants comprising this group of tumors.

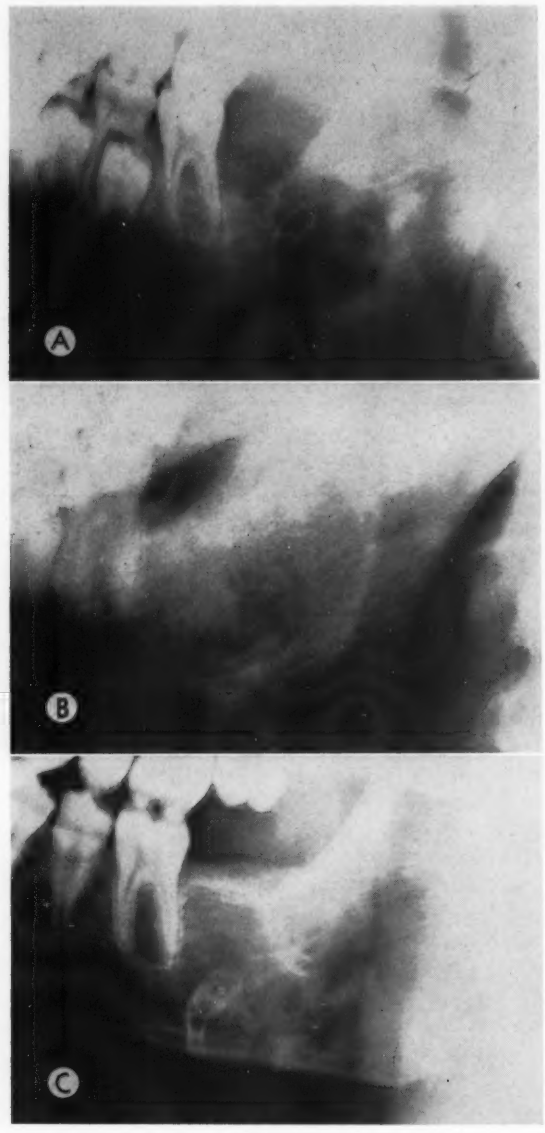

FIG. 14. Case XIII. (*A*) September, 1949: Cystic lesion of the left mandible before radiation therapy. The histopathologic report was that of giant cell tumor; on reviewing the slides the diagnosis was changed to ossifying fibroma or variant of monostotic fibrous dysplasia. (*B*) April, 1950: After administration of a total tumor dose of 864 r in 2 fractions over two months, there was definite improvement. (*C*) June, 1956: Roentgenographic study after seven years reveals normal appearance of the left mandible.

It is generally agreed that symptoms usually persist for from one to twenty months and consist of pain, swelling, tenderness and lameness. The tumors are most often found in children between the ages of twelve and twenty, predominantly in males, and are most frequent in the proximal epiphyses of the humerus but may be present in the upper and lower femur and upper and lower tibia. Coley and Santora[14] reported one case in the astragalus and one case in a metacarpal bone. Roentgenographically, they characteristically appear in the epiphyses as a rounded or oval area but may extend to the nearby metaphysis. There is an uneven mottled appearance due to calcific deposit within the cartilaginous tissue. Condensation of bone about the tumor is also present and, rarely, there is bulging of the cortex or involvement of the articular cartilage.

From the point of view of differential diagnosis, chondrosarcoma occurring in the epiphyseal region is of special significance. Copeland and Geschickter,[15] in a review of 25 cases diagnosed as chondroblastic tumor, found only 10 to be benign. The benign nature of the lesion was established only after re-study at follow-up examination. Two of the cases of Copeland and Geschickter were treated by biopsy and roentgen therapy with good results; 3 were amputated on the basis that they were malignant at the earlier study. Lichtenstein[32] feels that the malignant epiphyseal tumors are really chondrosarcoma and do not belong in this group. Even a biopsy in these cases is often of questionable value as the entire lesion must be carefully evaluated before evidence of malignancy can be assumed.

In view of this uncertainty in diagnosis by histologic examination, a conservative therapeutic approach might well be limited to irradiation and careful periodic observation to be followed by more radical procedures if the lesion progresses.

The typical giant cell tumor which oc-

Fig. 15. Case xiv. (*A*) June, 1943: Refracture through cystic area of the left mid femur after an open reduction and curettement remained unsuccessful. The histopathologic report was that of benign bone cyst. (*B*) December, 1943: Following administration of a total tumor dose of 169 r in 2 fractions over two months, there was good re-ossification. (*C*) May, 1947: Roentgenogram four years later discloses early malignant change. At this time hip disarticulation was performed. The second histopathologic report was that of periosteal fibrosarcoma. The patient was well in 1957.

curs in the same location is found in a slightly older age group, and almost always following epiphyseal closure. Also, it has coarser trabeculations, greater expansion, no periosteal reaction, and no mottling unless it has been previously treated. The response to irradiation is similar in both lesions so that little harm would be done in the treatment of a borderline case.

Of the cases reported in the literature, at least 8 were treated primarily by radiation therapy with only one unsatisfactory result. The dosage is not given except in one case recorded by Coley and Miller[13] in which an epiphyseal chondromatous giant cell tumor of the right upper humeral epiphysis was treated with three exposures of 700 r, for a total dose of 2,100 r in air. Five years later there was an excellent result. In Jaffe and Lichtenstein's[26] cases the dosage was indicated as "heavy" with subsequent stiffness of the knees in both cases treated. The improvement was satisfactory enough in the early cases so that Codman[10] felt that the ultimate result would be better if radiation therapy alone were used. Coley and Santora[14] state that radiation therapy might be an acceptable method of treatment; they report 3 cases treated by irradiation with good results. Copeland and Geschickter[15] suggest that biopsy followed by roentgen therapy should be the initial procedure in this group, since these tumors are more sensitive to radiation than the average cartilaginous tumor.

Included in our series is a proved case of this condition (Case xv, Fig. 16, *A*, *B* and *C*) which by original biopsy was termed an Ewing's tumor. Radical operation was not considered justified and radiation therapy

FIG. 16. Case XV. (*A*) August, 1938: Codman's tumor of the epiphysis of the left greater trochanter before radiation therapy. The first histopathologic report was that of Ewing's tumor, but on review the diagnosis was changed to Codman's tumor. (*B*) July, 1939: After administration of a total tumor dose of 2,356 r in 4 fractions over eleven months, there was definite improvement. (*C*) September, 1944: Roentgenogram made six years after institution of treatment shows good result. In 1957, twenty-nine years after treatment patient had normal use of her right leg. She is married and has 3 healthy children.

was administered with an excellent result. A tumor dose of 2,356 r was given in 4 fractions over a period of eleven months. Since the lesion was located in the epiphysis of the left greater trochanter and the patient was a female fifteen years of age, the ovaries were well protected during the irradiation. Twenty-nine years later she has normal use of the left lower extremity and is the mother of three healthy children. Subsequently, the microscopic sections were reviewed and a final diagnosis of a Codman's tumor (chondromatous giant cell tumor) was made.

DISCUSSION

In the cases of cystic-appearing lesions of long bones, reported in this series, biopsies originally obtained were variously interpreted as indicated in Table II. Based on long term observations, it is our impression that all of these solitary benign conditions behave similarly when treated by radiation therapy. The only justification for biopsy is to distinguish malignancy in a questionable case.

In 1929, Bloodgood in the preface of an article by Geschickter and Copeland[18] made the statement that "it is far safer to submit the x-ray photographs to others for help in diagnosis, employing radiation while waiting, than to perform a biopsy and send a section around for a diagnosis." It is doubtful that there should be any change in thinking from his approach, even today. Brailsford[8] has noted that only 5 per cent of some 1,500 cases collected by the American Registry of Bone Sarcoma were alive after five years and he believes that the 5 per cent were within the margin of error in diagnosis. He has found in reference to bone tumors that "every case of unquestionable sarcoma I have seen on whom a biopsy was performed, died within a few months."

In reviewing the literature, one not infrequently encounters examples of amputations and radical operations performed for what subsequently was demonstrated on closer study to have been a benign lesion, and nowhere is this more true than in solitary cystic-appearing lesions of long bones of children.

The results in the cases treated at Harper Hospital since 1922 have been above the average as compared to other methods. While radiation therapy cannot be used indiscriminately in children, and particularly about the metaphyseal areas, it has been noted over the years that careful application of small doses can achieve excellent results. The nature of these cystic-appearing lesions is, and has been the subject of much discussion and controversy. However, one can discern little difference in their response to irradiation.

From an exhaustive review of the literature and in the light of personal experience, it would appear that the majority of patients afflicted with such lesions do benefit from a trial of carefully administered irradiation. In the event that a desired result is not achieved following several weeks or months of observation, a surgical procedure can be instituted more effectively to complete healing in what then would be a more mature and more easily operable lesion. It is suggested that biopsy be done only after failure of irradiation and at the time of the contemplated curative surgical intervention.

CONCLUSIONS

1. Small fractionated doses of radiation repeated at intervals can produce excellent results in solitary cystic-appearing lesions of the long bones in children. A total tumor dose of 1,200 r need rarely be exceeded.

2. The exact type of benign cystic appearing lesion is relatively unimportant as all respond in similar manner to proper radiation therapy.

3. Radiation therapy can also be used to improve a poor surgical result.

4. In those instances where the desired result is not achieved by small amounts of irradiation, successful surgical intervention can be carried out subsequently.

5. The metaphysis can be adequately spared and bone growth continues normally.

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EDITORIAL

RADIATION EFFECTS ON BONE OF CHILDREN

THE degree of radiosensitivity exhibited by osseous tissues has been the subject of extensive investigations of a clinical and laboratory nature. Gradually, as the result of varying experiences, a substantial collection of evidence has been accumulated which indicates relative degrees of radiosensitivity in both normal and abnormal bone. As with other tissues, information in this regard can be obtained from three major sources. The susceptibility of benign and malignant osseous lesions to irradiation was perhaps the first of these to be utilized. Secondly, irradiation of bone unavoidably exposed in the treatment of other conditions permitted evaluation of its effects on adult and especially growing bone. Thirdly, the effects of certain radiations on bone have been experimentally studied in order to ascertain maximum permissible doses.

Dosage levels of radiation are of great interest when treating certain lesions of bone in children. Two considerations are foremost: (1) an assessment of optimum dosage for therapeutic efficacy, and (2) a concern for a possible relationship of this type of treatment to malignant transformation in this group.

Observation of the effects of radiation on benign and malignant lesions of bone has enabled the assessment of radiosensitivity in these pathologic states as well as in contiguous normal osseous and cartilaginous tissues. It has been repeatedly demonstrated that large doses must be delivered to bone and overlying tissues in order to control most malignant lesions. An exception to this is the Ewing's tumor of bone which evidences marked radiosensitivity. Benign cystic lesions of bone, due to their lesser growth potential and to their usual proximity to the growing ends of bone, require a smaller dose, and determining the optimum dose level has been the subject of many investigations. Most of these processes are at least partially inflammatory in nature and their similar response to roentgen therapy would indicate that their basic character is similar despite differing histologic composition. Some advantages of irradiation management have been repeatedly stressed. Infection, for example, can be avoided and surgical destruction of bone trabeculae is usually obviated. Repeated surgical intervention has resulted in malignant transformation of giant cell tumors in some series, but the same allegation has been made for protracted and fractionated roentgen therapy.

Woodard and Coley[1] have stated that the minimum effective dose in treating giant cell tumors of bone possibly lies between 1,500 and 2,500 r. This was deduced from the fact that no recurrences were observed in such tumors treated with 3,000 r and more, but several cases treated to this extent developed untoward radiation reactions in the skin and bone. They further observed that doses of 3,500 to 4,500 r decreased the ability of the normal bone to repair the products of breakdown and, therefore, demineralization resulted of a more or less permanent nature. Similarly, doses of 5,000 to 8,000 r resulted in very severe damage and/or death of normal bone. Woodard and Coley believe that a greater resistance to the effects of radiation exists in young bone than in adult bone. They caution that benign lesions in children should not be treated by irradiation

[1] WOODARD, H. Q., and COLEY, B. L. The correlation of tissue dose and clinical response in irradiation of bone tumors and of normal bone. AM. J. ROENTGENOL. & RAD. THERAPY, 1947, 57, 464–471.

but, if treated, should be managed with extreme care since radiation may exert a carcinogenic effect after a period of ten to fifteen years.

Experience gained from the administration of radiation therapy over growing sections of the skeleton for other types of malignancy has aided significantly in the understanding of these problems. Neuhauser, Wittenborg, Berman and Cohen[2] have made an outstanding contribution in their studies of the effects of roentgen therapy on the growing spine. They observed, in patients treated for Wilms' tumor, growth disturbances of the vertebrae which are related directly to the dose administered and inversely to the patient's age. Three types of damage were demonstrated roentgenographically by Neuhauser and his co-workers. These effects were observed in the vertebral bodies and are grouped according to severity which in turn is related to dosage. First, horizontal transverse lines of increased density with slight diminution in the cephalocaudal extent of the vertebral body were noted. Secondly, gross irregularity or scalloping of the vertebral epiphyseal cartilaginous plates was seen. Thirdly, gross abnormalities in the contour of the vertebral bodies were demonstrated. Neuhauser and his colleagues also found that tissue doses of less than 1,000 r produced no demonstrable damage irrespective of age, but that doses greater than 2,000 r resulted in damage regardless of age. Similarly, they observed that over the age of two years, doses of 1,000 to 2,000 r caused only minimum disturbances. In order to avoid producing scoliotic deformities, they recommended that the entire spine be included in the treatment field so that growth inhibitions, if produced, would be symmetric.

The same type of changes have been reported by Whitehouse and Lampe.[3] Although no tissue doses were given, a correlation between the intensity of irradiation and the degree of bone damage was observed. The length of protraction, magnitude of daily dose, field size, and the total dose were significant factors in assessing the radiation effects.

Much experimental work has been done in order to ascertain the exposure levels which lead to epiphyseal arrest, and it has been determined that 600 r or more to an epiphysis generally results in retardation of growth. Doses of less than 500 r result in no detectable stunting, and doses of 1,200 r or more lead to complete epiphyseal arrest. These are massive doses delivered at a single exposure.

When radiation is incriminated as a cause of malignant neoplasia, it may be asked: "Why does not bone fortuitously exposed during the treatment of other conditions undergo malignant transformation with greater frequency?" Patients receiving high doses of radiation to tissues over bone have been noted to develop malignant bone lesions in some instances, but certainly this incidence is very low. It should be recognized, however, that this problem is different in dealing with immature bone. Devitalization of osseous structures resulting in demineralization, avascularity and subsequent fracture are other effects which have been observed as the result of ionizing exposure in bone.

The unfortunate experience with the radium watch dial painters has made possible important studies on the carcinogenic effects of radiation. Martland[4] in 1931 first published an impressive series of these cases calling attention to the occurrence of bone sarcoma in these radioactive people.

Marked improvements in instrumentation have been made and radioactive assays are becoming increasingly more accurate. Looney and Colodzin[5] have carried out extensive investigations on the late ef-

[2] Neuhauser, E. B. D., Wittenborg, M. H., Berman, C. Z., and Cohen J. Irradiation effects of roentgen therapy on the growing spine. *Radiology*, 1952, *59*, 637–650.

[3] Whitehouse, M., and Lampe, I. Osseous damage in irradiation of renal tumors in infancy and childhood. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1953, *70*, 721–729.

[4] Martland, H. S. The occurrence of malignancy in radioactive persons. *Am. J. Cancer*, 1931, *15*, 2435–2516.

[5] Looney, W. B., and Colodzin, M. Late follow-up studies after internal deposition of radioactive materials. *J.A.M.A.*, 1956, *160*, 1–3.

fects of internal deposition of radioactive materials, and from this body of evidence we hope to gain further information as to maximum permissible dosage levels and to shed further light on the problem of late malignant transformation in bone as the result of radiation exposure.

Both anabolic and catabolic activities in bone are suppressed by irradiation, but it has been demonstrated that the degenerative function is more susceptible to alteration. It has been suggested that a differential effect of radiation on osteoclasts and osteoblasts may affect this response. One factor to bear in mind in ascertaining optimum dosage levels concerns the differential absorption of radiation in bone and soft tissue at varying energies. Spiers,[6] in studying the limitations of quantitative estimation of tumor doses in phantoms of various types, has shown that the presence of bone and lung tissue in the irradiated volume grossly affects radiation absorption. As is well known, the osteocytic and capillary tissue in the haversian systems of bone are the elements implicated in the radiation "reaction" of bone. The type of tissue surrounding the area of interest is a determining factor and the energy range of roentgen rays greatly influences the degree of ionization taking place. It has been demonstrated by Spiers[6] that the permissible dose in roentgens to bone is about one-half that tolerated by soft tissues in the 200 kv. range and may be no more than one-third for medium and superficial therapy ranges. He concluded that radiation of energy greater than 1 mev. is necessary to minimize damage to living elements within the bone. This concept has been well substantiated in subsequent absorption studies. Since most cystic lesions of bone are irradiated with energies in the medium and deep therapy range, is it possible that the published tissue doses may actually have been higher by a significant factor? In refutation of this concept, the contents of cystic lesions would more closely approach soft tissue in composition, and the character of the epiphyseal plate would also be more like that of soft tissue.

Newer studies of bone physiology coupled with extensive research on the effects of irradiation in water and other chemical systems will contribute further to our understanding of some of these factors pertaining to osseous radiobiology. Johnson,[7] in prefacing a bibliography on the structure, composition, and growth of bone, emphasizes that bone and the skeleton are in fact an organ system and that the complexities of chemical structure of elementary tissue components, the cellular makeup and the kinetics of enzyme systems as well as other factors may incite new concepts in the approach to these studies.

From the data cited it seems reasonable to conclude that dosage levels which are without uncommon hazard can be justifiably used in the management of certain lesions of bone in children. This is of particular importance in the treatment of benign cystic lesions of bone, since we hope to accomplish the best possible functional result in these young patients as well as to control the disease process.

Kenneth L. Krabbenhoft, M.D.

[6] Spiers, F. W. Dosage in irradiated soft tissue and bone (with an appendix by W. J. Meredith). *Brit. J. Radiol.*, 1951, *24*, 365–370.

[7] Spencer, M. C., and Uhler, K. The Structure, Composition and Growth of Bone. Armed Forces Medical Library Reference Division, Washington, D. C., March, 1955.

SOCIETY PROCEEDINGS

MEETINGS OF RADIOLOGICAL SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. Allen Good, Mayo Clinic, Rochester, Minn. Annual meeting: Shoreham Hotel, Washington, D. C., Sept. 30–Oct. 3, 1958.

American Radium Society
Secretary, Dr. Robert L. Brown, P.O. Box 459, Emory University, Ga. Annual meeting: The Homestead, Hot Springs, Va., April 6–8, 1959.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 713 E. Genesee St., Syracuse 2, N. Y. Annual meeting: Palmer House, Chicago, Ill., Nov. 16–21, 1958.

American College of Radiology
Executive Director, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Illinois. Annual meeting: Feb. 4–7, 1959, Chicago, Ill.

Section on Radiology, American Medical Association
Secretary, Dr. T. Leucutia, Harper Hospital, Detroit 1, Mich. Annual meeting: June 8–12, 1959, Atlantic City, N. J.

American Board of Radiology
Secretary, Dr. H. Dabney Kerr. Correspondence should be directed to Kahler Hotel Building, Rochester, Minn. Fall 1958 Meeting and Examinations Dec. 8–12, inclusive, Washington, D. C. Final date for filing applications was July 1, 1958. Special Examination in Nuclear Medicine for those diplomates in Radiology and Therapeutic Radiology, December 6, 1958, Washington, D. C.; deadline for filing applications is October 1. Special Spring Examination, March 16–19, 1959, Cincinnati, Ohio; deadline for filing applications is November 1, 1958. Candidates completing training June 30, 1959 are not eligible for the Spring 1959 examinations.

Ninth International Congress of Radiology
Secretary-General, Dr. Hans v. Braunbehrens. Request for information should be addressed to Dr. Viktor Loeck, Kongressbüro, Forsthausstrasse 76, Frankfurt am Main, Germany. Meets in Munich, Germany, July 23 to July 30, 1959.

Sixth Inter-American Congress of Radiology
Secretary for North America, Dr. Jorge de la Flor, Hospital Arzobispo Loayza, Lima, Perú. Meets in Lima, Perú, Nov. 2–8, 1958.

Alabama Radiological Society
Secretary Dr. J. A. Meadows, Jr., Medical Arts Bldg., Birmingham 5, Ala. Meets time and place Alabama State Medical Association.

American Nuclear Society
Executive-Secretary, Dr. W. W. Grigorieff, P. O. Box 963, Oak Ridge, Tenn. Annual meeting: To be announced.

Arizona Radiological Society
Secretary, Dr. R. Lee Foster, 1313 N. Second St., Phoenix, Ariz. Two regular meetings a year. Annual meeting at time and place of State Medical Association and interim meeting six months later.

Arkansas Radiological Society
Secretary, Dr. E. A. Mendelsohn, Holt-Krock Clinic, Fort Smith, Ark. Meets every three months and also at time and place of State Medical Association.

Association of University Radiologists
Secretary, Dr. Paul Riemenschneider, Medical College, State University of New York, Syracuse, N. Y. Annual meeting: Spring, 1959 in Atlanta, Ga.

Atlanta Radiological Society
Secretary, Dr. J. L. Clements, Jr., 35 Linden Ave., N.E., Atlanta 8, Ga. Meets monthly, except during three summer months, on second Friday evening.

Blockly Radiological Society
Secretary, Dr. Samuel Finkelman, 101 S. Twentieth St., Philadelphia, Pa.

Brooklyn Radiological Society
Secretary, Dr. Solomon Schwartz, 555 Prospect Place, Brooklyn, N. Y. Meets first Thursday of each month October through May.

Buffalo Radiological Society
Secretary, Dr. Charles Bernstein, 685 Delaware Ave., Buffalo 9, N. Y. Meets second Monday evening each month, October to May inclusive.

Central New York Roentgen Ray Society
Secretary, Dr. Joseph A. Head, 150 Marshall St., Syracuse, N. Y. Meets first Monday each month October through May.

Central Ohio Radiological Society
Secretary, Dr. Arthur R. Cohen, 41 S. Grant Ave., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, November, January, March and May at Fort Hayes Hotel, Columbus, Ohio.

Central Society of Nuclear Medicine
Secretary, Dr. Robert S. Landauer, Radiation Center Building, 1903 West Harrison St., Chicago 12, Ill.

Chicago Roentgen Society
Secretary, Dr. George B. Cahill, 802 Burns Ave., Flossmoor, Ill. Meets second Thursday of each month, October to April except December at the Sheraton Hotel at 8:00 P.M.

Cleveland Radiological Society
Secretary, Dr. Frederick A. Rose, 2065 Adelbert Rd., Cleveland 6, Ohio. Meetings at 7:00 P.M. on fourth Monday of each month from October to April at Tudor Arms Hotel.

Colorado Radiological Society
Secretary, Dr. Lorenz R. Wurtzebach, 601 E. Nineteenth Ave., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Connecticut Valley Radiologic Society
Secretary, Dr. Paul J. Kingston, 114 Woodland St., Hartford, Conn. Meets first Friday in February and April.

Dallas-Fort Worth Radiological Club
Secretary, Dr. A. H. Keene, 3707 Gaston Ave., Dallas, Texas. Meets monthly, third Monday, at Greater Fort Worth International Airport at 6:30 P.M.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. Joseph O. Reed, Jr., Harper Hospital, Detroit 1, Mich. Meets monthly first Thursday, October through May, at David Whitney House, 1010 Antietam, at 6:30 P.M.

East Bay Roentgen Society
Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

Eastern Radiological Society
Secretary, Dr. John D. Osmond, Jr., Euclid-Glenville Hospital, Cleveland 19, Ohio.

Florida Radiological Society
Secretary, Dr. C. Robert DeArmas 135 Broadway,

*** Secretaries of societies are requested to send timely information promptly to the Editor.**

Daytona Beach, Fla. Meets twice annually, in the spring with the annual State Society meeting, and in the fall.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. B. H. Malone, 1406 Reynolds St., Brunswick, Ga. Meets Spring and Fall with Annual State Society Meeting.

GREATER MIAMI RADIOLOGICAL SOCIETY
Secretary, Dr. George P. Daurelle, Jackson Memorial Hospital, Miami 36, Fla. Meets monthly third Wednesday at 8 P.M. at Jackson Memorial Hospital, Miami, Fla.

GREATER ST. LOUIS RADIOLOGICAL SOCIETY
Secretary, Dr. Charles J. Cherre, 462 N. Taylor, St. Louis 8, Mo.

HOUSTON RADIOLOGICAL SOCIETY
Secretary, Dr. Edward B. Singleton, 6621 Fannin St., Houston 25, Texas. Meets last Monday each month, Seminar Room, Doctors' Club of Houston.

IDAHO STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Charles R. McWilliams, Magic Valley Memorial Hospital, Twin Falls, Idaho. Meets annually at same time as Idaho State Medical Association.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Stephen L. Casper, 1101 Maine St., Quincy, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. A. Stayton, Jr., 313 Hume-Mansur Bldg., Indianapolis 4, Ind. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

IOWA RADIOLOGICAL SOCIETY
Secretary, Dr. James T. McMillan, 1104 Bankers Trust Bldg., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. The scientific section is held in the autumn.

KANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. James R. Stark, 3244 E. Douglas, Wichita, Kansas. Meets in spring with State Medical Society, and in winter on call.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. Robert H. Akers, 1405 West Broadway, Louisville 3, Ky. Meets monthly on second Friday at Seelbach Hotel, Louisville.

KINGS COUNTY RADIOLOGICAL SOCIETY
Secretary, Dr. C. P. Naidorf, 411 Parkside Ave. Brooklyn 26, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

LOS ANGELES RADIOLOGICAL SOCIETY
Secretary, Dr. Putnam C. Kennedy, 540 N. Central Ave., Glendale 3, Calif. Meets second Wednesday of month in September, November, March, April and June at Los Angeles County Medical Association Building, Los Angeles.

MAINE RADIOLOGICAL SOCIETY
Secretary, Dr. Francis J. O'Connor, Augusta General Hospital, Augusta, Maine. Meets in June, September, December and March.

MARYLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Nathan B. Hyman, 1805 Eutaw Place, Baltimore 17, Md.

MEMPHIS ROENTGEN SOCIETY
Secretary, Dr. James L. Booth, 899 Madison Ave., Memphis 3, Tenn. Meets first Monday of each month at John Gaston Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY
Secretary, Dr. S. F. Johnson, 2197 Los Arrow Dr., Dayton 9, Ohio. Meets second Friday of fall and winter months.

MID-HUDSON RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph Sorrentino, St. Francis Hospital, Poughkeepsie, N. Y. Meets 8:30 P.M., fourth Wednesday each month, September to May.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. Joseph F. Wepfer, 5000 W. Chambers St., Milwaukee 10, Wis. Meets monthly on fourth Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Donald H. Peterson, 853 Medical Arts Bldg., Minneapolis 2, Minn. Meets three times annually, in fall, winter and spring.

MISSISSIPPI RADIOLOGICAL SOCIETY
Secretary, Dr. Robert P. Henderson, 316 Medical Arts Bldg., Jackson, Miss. Meets third Thursday of each month at Hotel Edwards, Jackson, at 6:00 P.M.

MONTANA RADIOLOGICAL SOCIETY
Secretary, Dr. Arthur T. Austin, 104 The Doctors Bldg., Billings, Montana. Meets at least once a year.

NASSAU RADIOLOGICAL SOCIETY
Secretary, Dr. Jerome Zwanger, 126 Hicksville Rd., Massapequa, L. I., N. Y. Meets second Tuesday of the month in February, April, June, October and December.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. J. F. Kelly, Jr., 816 Medical Arts Bldg., Omaha, Neb. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. John E. Gary, 1180 Beacon St., Brookline 46, Mass. Meets third Friday of each month, October through May, at Hotel Commander, Cambridge, Mass.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY
Secretary, Dr. Paul Y. Hasserjian, 1470 Elm St., Manchester, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. Harold G. Jacobson, 210th St. and Bainbridge Ave., New York 67, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 4:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY
Secretary, Dr. William H. Sprunt, North Carolina Memorial Hospital, Chapel Hill, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Marianne Wallis, St. Joseph's Hospital, Minot, N. D. Meetings by announcement.

NORTH FLORIDA RADIOLOGICAL SOCIETY
Secretary, Dr. Marvin Harlan Johnston, Five Points Medical Center, Jacksonville 4, Fla. Meets quarterly in March, June, September and December.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY
Secretary, Dr. Irving Van Woert, Jr., Albany Hospital, Albany, N. Y. Meets in Albany area on second Wednesday of October, November, March and April.

NORTHERN CALIFORNIA RADIOLOGICAL SOCIETY
Secretary, Dr. Rob H. Kirkpatrick, 1219 28th St., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

OHIO STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Francis C. Curtzwiler, 421 Michigan St., Toledo 2, Ohio. Annual meeting: Cincinnati, Ohio, May, 1959.

OKLAHOMA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Edmond H. Kalmon, Jr., 300 Northwest 12th Street, Oklahoma City, Okla. Three regular meetings annually.

OREGON RADIOLOGICAL SOCIETY
Secretary, Dr. C. V. Allen, Veterans Hospital, Portland, Ore. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

ORLEANS PARISH RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets second Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY
Secretary, Dr. Robert W. Hanf, 900 S. Auburn, Kennewick, Wash. Meets annually in May.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco 8, Calif. Meets annually during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. Walter P. Bitner, 234 State St., Harrisburg, Pa. Annual meeting: Harrisburg, Pa., April 24–25, 1959.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. Roderick L. Tondreau, 3400 Spruce St., Philadelphia 4, Pa. Meets first Thursday of each month, at 5 P.M., from October to May in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. Edwin Beck, 3500 Fifth Ave., Pittsburgh 13, Pa. Meets second Wednesday of month, October through June at Park Schenley Restaurant.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. James K. V. Willson, 1100 N. Charles St., Baltimore 1, Md. Meets third Tuesday each month, September to May, inclusive.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Ted F. Leigh, Emory University, Georgia. Annual meeting: New Orleans, La., Nov. 3–6, 1958.

RADIOLOGICAL SOCIETY OF GREATER CINCINNATI
Secretary, Dr. Warner Peck, Carew Tower St., Cincinnati 2, Ohio. Meets monthly from September to May on first Monday of each month at 7:30 P.M. at the Cincinnati General Hospital.

RADIOLOGICAL SOCIETY OF HAWAII
Secretary, Dr. Jun-chu'an Wang, The Queen's Hospital Honolulu 9, Hawaii. Meets third Monday of each month alternately at 4:30 P.M. and 7:30 P.M.

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY
Secretary, Dr. E. H. Stratemeier, Jr., 1010 Rialto Building, Kansas City 6, Mo. Meets last Friday of each month.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA
Secretary, Dr. Seymour Ochsner, Ochsner Clinic, New Orleans 15, La. Meets annually during Louisiana State Medical Society meeting.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. Andrew P. Dedick, Jr., 67 E. Front St., Red Bank, N. J. Meets at Atlantic City at time of State Medical Society and in November in Newark, N. J.

RADIOLOGICAL SOCIETY OF NEW YORK STATE
Secretary-Treasurer, Dr Mario C. Gian, 610 Niagara St., Buffalo 1, N. Y. Annual meeting: To be announced.

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA
Secretary-Treasurer, Dr. Donald J. Peik, 303 S. Minnesota Ave., Sioux Falls, S. D.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA
Secretary, Dr. Harold P. Tompkins, 658 S. Westlake, Los Angeles 57, Calif.

REDWOOD EMPIRE RADIOLOGICAL SOCIETY
Secretary, Dr. Lee E. Titus, 164 W. Napa St., Sonoma, Calif. Meets second Monday every other month.

RICHMOND COUNTY RADIOLOGICAL SOCIETY
Secretary, Dr. W. F. Hamilton, Jr., University Hospital, Augusta, Ga. Meets first Thursday of each month at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. John W. Colgan, 277 Alexander St., Rochester 18, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. John H. Freed, 4200 East Ninth Ave., Denver 20, Colo. Annual meeting: Shirley Savoy Hotel, Denver, Colo., Aug. 14–16, 1958.

SAN ANTONIO-MILITARY RADIOLOGICAL SOCIETY
Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Texas. Meets third Wednesday each month in Fort Sam Houston Officer's Club at 6:30 P.M.

SAN DIEGO RADIOLOGICAL SOCIETY
Secretary, Dr. Stanley A. Moore, 2466 First Ave., San Diego 1, Calif. Meets first Wednesday of each month at the University Club.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. Irma Smith, 450 Sutter St., San Francisco 8, Calif. Meets quarterly at Grison's Steak House.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. William H. Graham, 630 East Santa Clara St., San Jose, Calif.

SECTION ON RADIOLOGY, CONNECTICUT STATE MEDICAL SOCIETY
Secretary, Dr. Ralph J. Littwin, Bristol Hospital, Bristol, Conn. Meetings are held bi-monthly.

SECTION ON RADIOLOGY, MEDICAL SOCIETY OF THE DISTRICT OF COLUMBIA
Secretary, Dr. Charles E. Bickham, Jr., 1835 Eye St., N.W., Washington 6, D. C. Meets Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. William Meszaros, 1825 W. Harrison St., Chicago, Ill.

SHREVEPORT RADIOLOGICAL CLUB
Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M. September to May inclusive.

SOCIETY OF NUCLEAR MEDICINE
Secretary, Dr. Robert W. Lackey, 452 Metropolitan Bldg., Denver 2, Colo. Annual meeting: To be announced.

SOUTH BAY RADIOLOGICAL SOCIETY
Secretary, Dr. Stanford B. Rossiter, 1111 University Dr., Menlo Park, Calif. Meets second Wednesday of each month.

SOUTH CAROLINA RADIOLOGICAL SOCIETY
Secretary, Dr. Wayne Reeser, 804 Burroughs St., Conway, S. C. One meeting with South Carolina Medical Association in May, others arranged by President.

SOUTHERN RADIOLOGICAL CONFERENCE
Secretary, Dr. Marshall Eskridge, Mobile Infirmary, Mobile, Ala.

SOUTHWESTERN RADIOLOGICAL SOCIETY
Secretary, Dr. Gordon Black, Suite 2-A, El Paso Medical Center, 1501 Arizona, El Paso, Texas. Meets second Tuesday of each month.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Range, P.O. Box 324, Johnson City, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. Miller, 3500 Gaston Ave., Dallas 10, Texas. Next meeting January 30 and 31, 1959, Statler-Hilton Hotel, Dallas, Texas.

TRI-STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Robert E. Beck, 600 Mary St., Evansville, Ind. Meets last Wednesday of Oct., Jan., March and May, 8:00 P.M. at Elks' Club in Evansville.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May, Service Memorial Institute.

UPPER PENINSULA RADIOLOGICAL SOCIETY
Secretary, Dr. A. Gonty, Menominee, Mich. Meets quarterly.

UTAH STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Angus K. Wilson, 343 S. Main St., Salt Lake City 1, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

Virginia Radiological Society
Secretary, Dr. Frank A. Kearney, II, 110 S. Curry St., Phoebus, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Wayne A. Chesledon, 306 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday of each month from September through May at 610 Pine St., Seattle.

West Virginia Radiological Society
Secretary, Dr. W. Paul Elkin, 515 Medical Arts Bldg., Charleston, W. Va. Meets concurrently with annual meeting of West Virginia State Medical Society; other meetings arranged by program committee.

Westchester Radiological Society
Secretary, Dr. Arnold Myron Wald, 406 Boston Post Road, Port Chester, N. Y. Meets on third Tuesday of January and October and on two other dates.

Wisconsin Radiological Society
Secretary, Dr. Farrell F. Golden, 5221 Tonyawatha Trail, Madison 4, Wis. Special meetings held during year; annual meeting each spring at Madison, Wis.

X-Ray Study Club of San Francisco
Secretary, Dr. John H. Heald, 450 Sutter St., San Francisco 8, Calif. Meets monthly, third Thursday at 7:30 P.M., Children's Hospital, September through June.

Cuba, Mexico, Puerto Rico and Central America

Asociación de Radiólogos de Centro America y Panamá
Comprising: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panamá, *Secretary-General*, Dr. Roberto Calderón, Calle Central Deste No. 218, Managua, Nicaragua. Meets annually in a rotating manner in the six countries.

Sociedad de Radiología y Fisioterapía Cubana
Secretary, Dr. Miguel A. García Plasencia, Hospital Curie, 29 y F, Vedado, Habana, Cuba. Meets monthly at Curie Hospital.

Sociedad Costarricense de Radiologia
Secretary, Dr. James Fernández Carballo, Apartado VIII, San José, Costa Rica.

Sociedad Mexicana de Radiología, A. C.
Calle del Oro No. 15, México 7, D. F.
Secretary-General, Dr. Guillermo Santín. Meets first Monday of each month.

Asociación Puertorriqueña de Radiología
Secretary, Dr. R. B. Díaz Bonnet, Suite 504, Professional Bldg., Santurce, Puerto Rico.

Sociedad Radiológica Panameña
Secretary, Dr. L. Arrieta Sánchez, Apartado No. 86, Panamá, R. de P. Meets monthly in a department of radiology of a local hospital, chosen at preceding meeting.

British Empire

Association of Radiologists of the Province of Quebec
Secretary, Dr. Isadore Sedlezky, 3755 Cote St. Catherine Rd., Montreal, Que. Meets four times a year.

British Institute of Radiology Incorporated with the Röntgen Society
Honorary Secretary, Dr. John Blewett, 32 Welbeck St., London, W. 1. Meets monthly from October until May.

Faculty of Radiologists
Honorary Secretary, Dr. R. A. Kemp Harper, 47 Lincoln's Inn Fields, London, W.C.2, England.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Canadian Association of Radiologists
Honorary Secretary, Dr. Guillaume Gill, *Associate Honorary Secretary*, Dr. Robert G. Fraser, 1555 Summerhill Ave., Montreal 25, Que. Meetings January and June.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Française d'Electro-Radiologie Médicale
General Secretary, Dr. Louis Ivan Vallée, 1058 rue St. Denis, Montreal 18, Canada. Meets third Saturday each month.

Toronto Radiological Society
Secretary, Dr. L. R. Harnick, Toronto Western Hospital, 399 Bathurst St., Toronto, Ontario. Meets second Monday of each month September through May.

College of Radiologists of Australasia
Honorary Secretary, Dr. Arthur B. Sullivan, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W., Australia.

South America

Asociación Argentina de Radiología
Secretary, Dr. Lidio G. Mosca, Avda. Gral. Paz 151, Córdoba, Argentina. Meetings held monthly.

O Colégio Brasileiro de Radiologia
Secretary-General, Dr. Walter Bomfins Pontes. Seat: Rua Major Quedinho, 99-2°. Andar, São Paulo, Brazil.

Sociedad Argentina de Radiología, Junta Central, Buenos Aires
Secretary, Dr. Juan L. Ambrogna, Montevideo 745, Buenos Aires. Meetings are held monthly.

Sociedade Brasileira de Radiologia Medica
Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.

Sociedade Brasileira de Radioterapia
Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

Sociedad Chilena de Radiologia
Secretary, Dr. Armando Doberti, Merced 565, Santiago, Chile. Meets fourth Friday of each month.

Sociedad Colombiana de Radiologia
Secretary, Dr. Alberto Mejia Dzg., Carrera 13, No. 25-31, Apartado aéreo No. 5804, Bogotá, Colombia. Meets last Thursday of each month.

Sociedad Ecuadoriana de Radiologia y Fisioterapia
Secretary, Dr. Enrique Ortega Guzmán, Casilla 4719, Guayaquil, Ecuador.

Sociedad Peruana de Radiologia
Secretary, Dr. Luis Pinillos G., Apartado 2306, Lima, Perú. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta 218, Lima.

Sociedad de Radiologia del Atlantico
Secretary, Dr. Raul Fernandez, Calle 40 #41-110, Baranquilla, Colombia. Society meets monthly at the Instituto de Radiologia.

Sociedad de Radiología, Cancerología y Física Médica del Uruguay
Secretary-General, Dr. Ricardo Parada, Av. Agraciada 1464, Piso 13, Montevideo, Uruguay.

Sociedade de Radiologia de Pernambuco
Secretary, Dr. Manoel Medeiros, Instituto de Radiologia da Faculdade de Medicina da Universidade do Recife, Caixa Postal 505, Pernambuco, Brazil.

Sociedad Venezolana de Radiología
Secretary-General, Dr. Sebastian Nuñez Mier y Téran, Apartado No. 9362, Caracas, Venezuela. Meets monthly third Friday at Colegio Médico del Distrito Federal, Caracas.

Continental Europe

Austrian Roentgen Society
President, Dr. Konrad Weiss, Mariannengasse 10, Vienna 9, Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.

Société Belge de Radiologie
General Secretary, Dr. S. Masy, 256 Chaussée de Wavre,

Heverlee-lez-Louvain, Belgium. Meets in February, March, May, June, October, November and December.

Société Française d'Électroradiologie Médicale, and its branches: Société du Sud-Ouest, du Littoral Méditerranéen, du Centre et du Lyonnais, du Nord, de l'Ouest, de l'Est, et d'Alger et d'Afrique du Nord. Central Society meets third Monday of each month, except during July, August and September, rue de Seine 12, Paris.
Secretary-General, Dr. Ch. Proux, 9, rue Daru, Paris 8e, France. National Meeting Oct. 15–17, 1958 in Paris.

Ceskoslovensk společnost pro Rëntgenologii a Radiologii v Praze
Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

Deutsche Röntgengesellschaft
Secretary, Professor Dr. med. H. Lossen, Universitäts-Röntgeninstitut, Lagenbeckstr. 1, Mainz, Germany. Meets beginning of Oct., 1958 in Bremen. President of Congress, Professor Dr. du Mesnil de Rochemont, Universitäts—Strahlenklinik, Marburg, Germany.

Società Italiana di Radiologia Medica e di Medicina Nucleare
Secretary, Dr. Ettore Conte, Ospedale Mauriziano, Torino, Italy. Meets annually.

Nederlandse Vereniging voor Electrologie en Röntgenologie
Secretary, Dr. J. R. von Ronnen, Violenweg 14, den Haag, Netherlands.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. D. Aureo Gutierrez Churruca, Esparteros, No. 9, Madrid, Spain. Meets monthly in Madrid.

Schweizerische Röntgengesellschaft (Société Suisse de Radiologie)
Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

India

Indian Radiological Association
Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay 1, India.

The next list of Meetings of Radiological Societies will be published in the November issue of the Journal.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

PEDIATRIC ROENTGENOLOGY. By Dr. M. A. Lassrich, Prof. Dr. R. Prévôt, and Prof. Dr. K. H. Schäfer, Hamburg. Translation from the German provided by James T. Case, M.D., D.M.R.E. (Cambridge), Professor Emeritus, Radiology, Northwestern University Medical School, Chicago; Director, Memorial Cancer Foundation, Santa Barbara, California. Cloth. Price, $28.00. Pp. 328, with 700 illustrations. Grune & Stratton, Inc., 381 Fourth Avenue, New York 16, New York, 1957.

This atlas of pediatric roentgenology, translated from the German by Dr. James T. Case, is beautifully printed and magnificently illustrated with more than 700 roentgenograms. The quality of the reproductions deserves the highest praise and the introductory remarks and captions for the illustrations are succinct and lucid.

The text is divided into three major sections: thoracic organs, abdominal organs, and the skeletal system, and there are numerous subdivisions. Each has a general introduction with a brief discussion of methods and techniques which should prove helpful to many roentgenologists reflecting, as they do, the thoughtfulness and experience of the authors. The legends accompanying the illustrations not only describe the lesion or abnormality presented, but usually indicate very briefly variations in the picture that may be expected.

In the introduction the authors apologize for the necessity of limiting the text and number of illustrations so that this volume could be produced at a reasonable cost, although at $28.00 it is expensive enough. It is natural, therefore, that many diseases are not mentioned, others illustrated only by reproductions of a single roentgenogram, and as is the usual tendency, this represents the far advanced picture. It is, of course, a truism that it is not possible to present the entire course of a disease process by a single illustration. This has made some portions of the book inadequate and this reviewer fears that this type of brief presentation furthers the student's tendency to diagnose by comparison of illustrations rather than by interpretation of film from a basic understanding of the etiology, pathology, and pathogenesis of a disease. The authors realize and apologize for this deficit.

This atlas is thoroughly commendable in all other ways and the authors, the translators and the publishers are to be congratulated on this most satisfactory presentation and condensation of an extraordinarily difficult and extensive subject.

EDWARD B. D. NEUHAUSER, M.D.

ROENTGEN DIAGNOSIS OF ABDOMINAL TUMORS IN CHILDHOOD. By Charles M. Nice, Jr., M.D., Ph.D., Alexander R. Margulis, M.D., and Leo G. Rigler, M.D., all from the Department of Radiology, University of Minnesota Medical School, Minneapolis, Minnesota. Cloth. Price, $4.00. Pp. 75, with 52 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1957.

This monograph is mainly a presentation of a simple systematic roentgen approach in the diagnosis of abdominal masses. The lesions included were chosen either because they are more common or because they are good examples for the presentation of the method and some of its points.

The material discussed includes (a) intraperitoneal masses in the region of the liver; (b) other intraperitoneal masses; (c) renal and adrenal masses; (d) other extraperitoneal masses. There is also a brief presentation of the anatomy and embryology of the intestinal tract.

Intraperitoneal masses in the region of the liver comprise primary hepatoma, sarcoma, hepatic cyst, choledochal cyst, and generalized enlargement of the liver due to other causes.

The group of other intraperitoneal masses includes the enlarged spleen, mesenteric and omental cysts, lymphangioma of the mesentery, alimentary duplication cyst, meconium ileus, ovarian tumors, intussusception, appendiceal abscess, and subphrenic abscess.

The renal and adrenal masses discussed are hydronephrosis, Wilms's tumor, renal carcinoma, renal cysts, polycystic disease, anomalies of

renal fusion, abscess and adrenal tumors of various types.

The other extraperitoneal masses were found to fall into three categories, namely: (1) tumors arising in organs normally present in extraperitoneal space (kidney, adrenal, pancreas, uterus, prostate); (2) primary unattached tumors; (3) primary metastatic tumors involving the retroperitoneal lymph nodes.

The monograph is an excellent example of the utilization of the more simple roentgen studies in their application to the diagnosis of abdominal tumors in infants and children. The exact locations of the lesions are discussed along with observations and diagnostic features in relation to general appearance, size, outline, change in contour, the presence of calcification or formed structures within the mass. The importance of a satisfactory roentgen technique is emphasized.

This monograph is highly recommended for reading because of its concentrated and integrated roentgenographic information.

James F. Martin, M.D.

Chemical Anthropology. By Icie G. Macy' and Harriet J. Kelly. Price, $3.75. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Illinois, 1957.

This small book, *Chemical Anthropology* by Icie G. Macy and Harriet J. Kelly, summarizes the results of many years of pioneering in some phases of the investigative work on children. It is done in such a way that it will help all workers in the field. The authors consider that the data on which it is based will form the groundwork for a chemical evaluation of human growth processes.

We all know that there is a great deal more to proper growth and development of children than appears on the surface. Certainly it should be axiomatic that proper heredity and good nutrition are necessary for the body "as a whole" and also for each and every part of it. The very cells that make up the tissues are concerned, and it is with improving their opportunities that all of us in this field are interested.

As a physician, I think first in terms of prevention and then of helping those in whom something has gone wrong. In any evaluation we immediately consider genetic differences and nutritional factors. Almost everyone is interested in the proper growth of children; yet, despite this interest, little still is known. We do not even know how many factors enter into the problem because, for the most part, control of a child's growth takes place automatically. The child, of course, gives little or no thought to the calories he obtains or the mechanisms involved. Yet, the fundamental principles have operated over and over in individuals for countless centuries without any planning whatsoever on our part. This does not mean that we should not know the regulatory mechanisms which function and how they regulate with such remarkable precision. In fact, we all look forward to the day when we must understand the "why" of growth and how it may have various patterns of change at different ages. Even the problem of why some children eat "too much" and others eat "too little" is not understood.

Very properly this treatise is based on the study of individuals. Until we become better acquainted with the differences in metabolism of children, we are not in position to obtain much data about what is truly wrong in the child who does not grow properly. As physicians, how can we hope to cope successfully with these difficult problems until we know more?

This presentation will aid in understanding the findings of the authors in this complicated field. They have done an excellent job of presenting the essential facts they have obtained. They would be the first to admit that the present contribution offers only a shred of the information that will be necessary for our understanding of the complex story of the growth and development of children.

It is important that we consider growth as the sum of many structural and metabolic changes that occur throughout the body. This concept is well accepted in medicine and was stressed by the great physiologist, Claud Bernard, who emphasized that the living being must be treated as a harmonious whole. It seems to me that no one properly regards the complexity of human growth, in that many systems can proceed to grow at different rates and yet in a normal fashion. There is an underlying orderliness of these physical processes, and it is about the measurements of some of these processes that the authors have written. As the authors have viewed the situation, the measurements have been pretty well restricted to the effects of proteins and minerals. Fat, water, vitamins and carbohydrates are pretty much ignored, and this might leave some of the readers with the feeling that bone growth could well occur without them being involved. These

remarks are included not as criticism of the authors' presentation, for they certainly know all the facts, but simply as additional way of stressing for the readers of this review that they should look at growth as the sum of many structural and metabolic changes throughout the body.

Tom D. Spies, M.D.

Dynamic Anatomy and Physiology. By L. L. Langley, Ph.D., LL.B., Associate Professor of Physiology, University of Alabama Medical Center; E. Cheraskin, M.D., D.M.D., Professor and Chairman of the Department of Oral Medicine, University of Alabama Medical Center; and Ruth Sleeper, R.N., Director of the School of Nursing, Massachusetts General Hospital. Cloth. Price, $6.00. Pp. 719, with 313 illustrations. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York, 1958.

As the title of this textbook for nursing students implies, the emphasis formerly placed on anatomy and physiology separately has been reduced and the two combined to provide better understanding of the total human body. This approach is commendable since it creates greater interest in what has ordinarily been a dry subject to be assimilated only by forced memorizing.

Each chapter has a summary emphasizing the material covered and a list of guiding questions as well as a number of pertinent references.

The illustrations and typography are excellent, making this a well organized, instructive and stimulating text.

William S. Reveno, M.D.

Die hüftnahen Femurosteotomien; Unter Berücksichtigung der Form, Funktion und Beanspruchung des Hüftgelenkes. By Priv.-Doz. Dr. M. E. Müller, Zürich. Cloth. Price, DM 49.50. Pp. 184, with 282 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1957.

The writing of this monograph was stimulated by the poor results following many of the arthroplastic procedures and prosthetic replacement procedures employed for various hip joint disabilities in recent years. The author's personal belief that osteotomy in the upper end of the femur has greater possibilities for the relief of hip joint disability than is generally recognized was an additional stimulus for the production of this monograph.

The monograph itself is divided into two parts, a general part and a special part. Historically, the author gives credit to Reah Barton, an American, for having performed the first corrective osteotomy of the femur with a favorable result. This was accomplished on November 22, 1826. The author then goes on to discuss the normal mechanical relationships of the hip joint and the considerations and measurements necessary to restore as nearly as possible these relationships in various hip joint disabilities. He describes the mechanical advantages to be gained by the various types of intertrochanteric osteotomy. By changing the neck shaft angle in the frontal plane, the position of the greater trochanter can be altered, which, in turn, may change the line of pull of the abductor muscles and increase their effectiveness. By changing the neck shaft angle in the sagittal plane, the center of gravity may be shifted with a resulting decrease in lumbar lordosis and an increase in the patient's standing stability. By changing the neck shaft angle in the horizontal plane, the ante torsion may be corrected and the head of the femur directed into the center of the acetabulum. By displacement of the femoral shaft, the relationship between the mechanical axis of the femur and the center of gravity of the hip joint can be altered with resulting functional advantage. To determine the level of the osteotomy and the angle after the type of osteotomy has been determined, the author makes use of a so-called x-ray ischiometer made of plexiglas. This measuring device, in conjunction with the exacting roentgenographic technique employed, is fully described.

In the special part of the monograph, the author states that 297 osteotomies of the upper end of the femur were performed between May, 1952 and July, 1956. These osteotomies were done for various hip joint disabilities including old cases of hip subluxation and hip dislocation, congenital coxa vara, epiphysiolysis of the head of the femur, pseudoarthrosis of the neck of the femur and aseptic necrosis of the head of the femur, paralyses due to poliomyelitis and cerebral palsy, coxarthrosis of various types and tuberculous coxitis. The type of osteotomy and the surgical technique employed in treating these various disabilities is described in detail. The advantages of various

types of instruments and plates used for internal fixation after osteotomy are also described.

This is a stimulating and worthwhile treatise on a very important and controversial subject at the present time. It is recommended reading for any surgeon who is attempting to deal with the various hip joint disabilities, pointing out as it does the possibilities of osteotomy in comparison with the more radical procedures of arthroplasty and hip replacement prostheses. It is also recommended reading for the roentgenologist who may be called upon by the surgeon to assist in determining the exact site and type of osteotomy to be employed for the maximum relief of the particular disability.

Frederick J. Fischer, M.D.

Dr. W. C. Röntgen. By Otto Glasser, Ph.D., F.A.C.R. (Assoc.), Holder of Röntgen-Honor-Plaque of the Röntgen-Museum in Remscheid-Lennep, 1951; Professor of Biophysics, Frank E. Bunts Educational Institute; Head, Department of Biophysics, Cleveland Clinic Foundation, Cleveland, Ohio. Second edition. Cloth. Price, $4.50. Pp. 196, with 26 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1958.

In this second edition of his supplementary biography of Röntgen, Dr. Glasser has added nothing that is new with the exception of substitution of new for some of the old illustrations. Additional references to source material have also been given, but these are said by the author to represent relatively few new points of view.

The essential story of Röntgen's life and the events leading up to his classical education and life's work in physics culminating in the discovery of x rays are given in an easily readable style. The story of the youth Röntgen who fortunately overcame a number of obstacles to acquire an academic education is an excellent example for those who would follow a scientific career today. Many people have the mistaken idea that Röntgen accidentally discovered the x rays without realizing that this event represented the logical outcome of a mind disciplined by and obedient to the laws of physics. A list of notable scientific papers and discoveries in the field of physics which he made before the age of fifty when he discovered the unknown rays is given.

Throughout the book Röntgen stands as an exemplary scientist who used imagination and experimented, but always checked his theories carefully by objective methods. Not until he was certain of the exact character and properties of x rays did he attempt to make any scientific report about them. To all radiologists who are not already thoroughly acquainted with the achievements of the famed physicist, Röntgen, this book is recommended for a captivating evening's reading.

Lewis E. Etter, M.D.

BOOKS RECEIVED

Tumors of the Liver and Intrahepatic Bile Ducts. Atlas of Tumor Pathology. Section VII—Fascicle 25. By Hugh A. Edmondson, M.D., Professor of Pathology, University of Southern California, School of Medicine, Los Angeles, California. Paper. Price, $2.25. Pp. 216, with 207 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D. C., 1958. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D. C.

Tumors of the Skin. Atlas of Tumor Pathology. Section I—Fascicle 2. By Herbert Z. Lund, M.D., Director of Laboratories, The Moses H. Cone Memorial Hospital, Greensboro, North Carolina, Visiting Professor of Pathology, University of North Carolina, Chapel Hill, North Carolina. Paper. Price, $3.00. Pp. 330, with 265 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D. C., 1957. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D. C.

Tumors of the Esophagus. Atlas of Tumor Pathology. Section V—Fascicle 20. By Arthur Purdy Stout, M.D., Professor of Surgery, Emeritus, and Professor of Pathology, Retired, Columbia University, College of Physicians and Surgeons; and Raffaele Lattes, M.D., Professor of Surgery, Columbia University, College of Physicians and Surgeons. Paper. Price, $1.00. Pp. 105, with 58 illustrations. Published by the Armed Forces Institute of Pathology under the Auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D. C., 1957. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D. C.

Medical Electrical Equipment; Principles, Installation, Operation and Maintenance of Electrical Equipment Used in Hospitals and Clinics. Advisory Editor, Robert E. Molloy,

M.B., F.F.A., R.C.S. Cloth. Price, $15.00. Pp. 312, with numerous illustrations. Philosophical Library Inc., 15 East Fortieth Street, New York 16, New York, 1958.

Studies on Protein-Bound Carbohydrates in Human Serum and Urine in Proteinuria. The Scandinavian Journal of Clinical & Laboratory Investigation, Supplement 32. By B. Laurent. Paper. Pp. 84, with 16 illustrations. Enjar Munksgaard, 6 Nörregade, Copenhagen K, Denmark, 1958.

Diseases of the Esophagus. By J. Terracol, Professor of the Faculty of Medicine of Montpellier, France; and Richard H. Sweet, Associate Clinical Professor of Surgery, Harvard Medical School. Cloth. Price, $20.00. Pp. 682, with 409 illustrations. W. B. Saunders Company, 218 West Washington Square, Philadelphia 5, Pennsylvania, 1958.

Pulsatory Activity of Peripheral Arteries. The Scandinavian Journal of Clinical & Laboratory Investigation, Supplement 30. By Per S. Wehn. Paper. Pp. 106, with 56 illustrations. Enjar Munksgaard, 6 Nörregade, Copenhagen K, Denmark, 1957.

Röntgenanatomie der Neugeborenen- und Säuglingslunge. By Priv.-Doz. Dr. med. habil. Z. Zsebök, Budapest. Cloth. Price, DM 75.-. Pp. 160, with 286 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

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ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Abdomen

Cojan, P.: Contribution to the radiology of the operated-on stomach 541

Loéwy, G.: The radiologic aspects of prolapse of the gastric mucosa into the duodenal bulb. 541

Rosenberg, M. A., and Elkin, M.: Gastric deformity from extrinsic pressure by calcified splenic artery 542

Hartzell, H. V., and Chesledon, W. A.: The amplifying fluoroscope; comparison with conventional fluoroscope in two thousand examinations of the stomach 542

Kaufman, S. A., and Levene, G.: Postbulbar duodenal ulcer 542

Figiel, S. J., Figiel, L. S., and Rush, D. K.: Study of colon by use of high-kilovoltage spot-compression technique 542

Wietersen, F. K., and Balow, R. M.: Colonic endometriosis: Roentgenologic aspects ... 542

Hodge, J., Barrick, C., and McLaughlin, E.: Biliary dyskinesia in T-tube cholangiography 543

McConnell, F.: Malignant neoplasm of the gallbladder: Roentgenological diagnosis 543

Lowman, R. M., and Davis, L.: The role of barium contrast studies in the diagnosis of retroperitoneal tumors 543

Genitourinary System

Piemonte, M., and Magno, L.: On the renal elimination of iodine-containing contrast media 543

Wohl, G. T.: Use of contrast media in the recognition of hypertension of renal origin 544

Weiner, M. E., Alcorn, F. S., and Jenkinson, E. L.: Subcapsular rupture of the kidney during intravenous urography 544

Evans, J. A.: Nephrotomography in the investigation of renal masses 544

Caine, M., and Edwards, D.: The peripheral control of micturition: A cine-radiographic study 545

Van Woert, I., Jr., Kearney, P. I., Kilicozlu, I., and Roach, J. F.: Radiation hazards of intravenous pyelography 545

Giraud, M., Bret, P., Kuentz, M., Anjou, A., Costaz, G., and Chollat, L.: Radiologic and stratigraphic study of adrenal tumors; report of 11 cases, 3 of which showed bilateral involvement 546

Steinbach, H. L., Hinman, F., Jr., and Forsham, P. H.: The diagnosis of adrenal neoplasms by contrast media 546

Nägele, E.: Roentgen findings in alkaptonurie 546

Nervous System

Grosjean, M.: On the use of pantopaque in myelographies 547

Skeletal System

Reinhardt, K.: Rotational vertebral gliding and its clinical importance 547

Schwarz, G. S.: Bilateral antecubital ossicles (fabellae cubiti) and other rare accessory bones of the elbow; with a case report 547

Fineman, S.: Newer methods for symmetrical roentgenography of the intervertebral foramina of the cervical spine and optic foramina 547

Pirkey, E. L., and Purcell, J. H.: Agenesis of lumbosacral vertebrae; a report of two cases in living infants 548

Schneider, C. C., and Melamed, A.: Spondylosis and spondylolisthesis; case report clarifying the etiology of spondylolysis 548

Eisemann, G., Rubin, S., and Dann, D. S.: Early clinical and x-ray diagnosis of multiple myeloma 548

Fischgold, H., Juster, M., and Écoiffier, J.: Microradiographic study of epiglandular osseous metastases 549

DeVries, P. H., Badgley, C. E., and Hartman, J. T.: Radiation sterilization of homogenous-bone transplants utilizing radioactive cobalt 549

Blood and Lymph System

Evans, A. T.: Renal cancer: Translumbar arteriography for its recognition 549

Wyatt, G. M., and Felson, B.: Aortic thrombosis as a cause of hypertension: An arteriographic study 550

General

Hellström, J., Birke, G., and Edvall, C. A.: Hypertension in hyperparathyroidism 550
Buice, J. W., and Gould, D. M.: Abdominal and pelvic pneumography 551

RADIATION THERAPY

Friedman, M., and Schwartz, E. E.: Irradiation therapy of pigmented villonodular synovitis 551
Brunschwig, A., and Daniel, W.: The surgical treatment of cancer of the cervix uteri .. 551
Stevenson, C. S.: The treatment of carcinoma of the cervix with full irradiation therapy followed by radical pelvic surgery; first progress report on an experimental series 552
Schoen, D.: Clinical considerations regarding the cause and treatment of radiation leukopenia 552
Widmann, H.: The reaction of leukopoiesis after fractionated short-term whole body irradiation 553
Kaplan, H. S.: Radiation research and the future of radiotherapy 553

RADIOISOTOPES

Cassidy, C. E., and VanderLaan, W. P.: Laboratory aids to diagnosis in thyroid disease 554
Doering, P., and Kramer, K.: Determination of weight of the thyroid gland by scintigraphy after administration of radioactive iodine: A contribution to radioisotope dosage 554
Chears, W. C., Jr., McCraw, B. H., Tyor, M. P., and Ruffin, J. M.: The I^{131} labeled triolein absorption test: Reproducibility and factors affecting blood levels 554
Schumacher, W., and v. Oldershausen, H.-F.: Hepatic function test with I^{131} tagged rose bengal 555
von Harnack, G.-A., Horst, W., Lenz, W., and Zukschwerdt, L.: Homotransplantation of thyroid tissue between uni-ovular twins .. 555
Johnson, P. C., Bird, R. M., and Smith, C. W.: Liver counting of cobalt-60 labeled vitamin B-12 in the diagnosis of pernicious anemia 556
Matthes, T., and Kriegel, H.: Deposition of thorium dioxide in the gonads of rabbits and human; (an autoradiographic study) 556

ROENTGEN DIAGNOSIS

Abdomen

Cojan, P. (Chaumont, France.) Contribution à la radiologie de l'estomac opéré. (Contribution to the radiology of the operated-on stomach.) *J. de radiol., d'électrol. et de méd. nucléaire*, Nov.–Dec., 1957, *38*, 1062–1068.

Knowledge of the complications of subtotal gastrectomy will be useful: (1) To the clinician, by allowing him to refer to their actual origin—a series of disorders improperly labelled until recently as dumping syndrome or peptic-jejunal ulcer; (2) to the surgeon, so that he may prevent such complications in the course of the operation; and (3) to the radiologist by instigating him to perform systematically a reflux investigation, a thorough study of the cardia and, in insufflation, of the stump.

Technique—A spoonful of opaque material (mucellose) is given, and the following studies are made: A spot film series of the cardia; a series of the stoma and anastomotic loops under compression, at various angles; a series of the stump with compression; another series of the stoma and anastomotic loops without compression. An effervescent powder is then administered and the cardia is roentgenographed in oblique and lateral views. As gas escapes through the stoma double contrast spot roentgenograms of this area are obtained. The stomach is now completely filled, and a search for reflux is made; finally large horizontal oblique roentgenograms are taken. If a syndrome of the afferent loop is suspected, intravenous cholangiography can be done at a different time to study the duodenal stasis.

With studies such as these the percentage of dumping syndromes which cannot be explained roentgenologically has become much lower. The following diagnoses were made in 200 postoperative examinations:

Painful distention of the stump	18
Cardio-tuberosity anomalies	35
Compression or stenosis of the loop or stoma	20
Syndromes of the afferent loop	3
Evaginations or invaginations of gastric or duodenal mucous membranes	15
Fistulas	2
Malignant relapses or carcinoma	12
Ulcerous relapses	15
Gastritis, stomitis, jejunitis	25
Miscellaneous	45.

—*Frank A. Riebel, M.D.*

Loéwy, Gabriel. Les aspects radiologiques du prolapsus de la muqueuse gastrique dans le bulbe duodénal. (The radiologic aspects of prolapse of the gastric mucosa into the duodenal bulb.) *J. de radiol., d'électrol. et de méd. nucléaire*, Sept.–Oct., 1957, *38*, 916–923. (From: Service du Dr. J. P. May, Hôpital d'Ivry, Paris, France.)

Evagination or prolapse of the gastric mucosa into the duodenal bulb indicates a penetration of the gastric mucosal folds across the pylorus into the duodenal bulb. This was first recognized and so identified by Schmieden in 1911, during a surgical exploration. Eliason and Wright (1925) were the first to publish roentgenologic evidence of this condition. For quite some time, only sporadic reports appeared in the literature. More recently, however, numerous articles were published on the subject from many countries, while a paucity of information still exists in the French literature.

The author stresses the importance of careful fluoroscopic examination, serial spot films and good roentgenographic technique in arriving at a correct diagnosis. The reported incidence is between 2–5 per cent of all roentgenologic examinations of the gastroduodenal area, which is about the same incidence as that of gastric ulcers.

Prolapse of the gastric mucosa through the pylorus occurs most frequently in males over fifty years of age. It is not encountered before the age of twenty.

The deformity is observed at the base of the duodenal cap; it is described as mushroom-shaped, parachute-like, cauliflower-type, or resembling an atomic mushroom. There should be no problem in differential diagnosis since the deformity is so typical in its location and appearance. Other conditions, such as ulcers and tumors, present a well known and characteristic image.

Quoting Melamed, the author presents the following classification:

Primary Prolapse:
- Hypermotility of the folds
- Congenital hypertrophy of the folds

Secondary Prolapse (Reversible following treatment of the cause):
- (1) Benign:
  - (a) Inflammatory
    - Antral gastritis
    - Hypertrophic gastritis
    - Gastric ulcer
    - Duodenal ulcer
  - (b) Submucosal edema of the stomach
    - Cardiac insufficiency
    - Hypoproteinemia—reversal of albumin/globulin ratio
    - Pyloric hypertrophy
  - (c) Other causes
    - Vitamin B deficiency
    - Trauma
- (2) Malignant:
  - (a) Neoplasia
  - (b) Lymphoid leukemia?

One diagram and 19 reproductions of roentgeno-

grams accompany this excellent article.—*William H. Shehadi, M.D.*

ROSENBERG, MURRAY A., and ELKIN, MILTON. Gastric deformity from extrinsic pressure by calcified splenic artery. *Radiology*, Nov., 1957, *69*, 735–738. (Address: M. A. Rosenberg, Albert Einstein College of Medicine, New York 61, N. Y.)

Abdominal roentgenograms of elderly patients will frequently reveal vascular calcification, particularly calcification of the splenic artery branch of the celiac artery. The splenic artery branch proceeds to the left, behind the stomach, and courses along the superior border of the pancreas to the hilus of the spleen. The course is normally tortuous and this tortuosity becomes more pronounced with aging. Consequently, an exceptionally tortuous splenic artery, which has become rigid due to calcific atherosclerosis, may produce an extrinsic pressure defect simulating an intrinsic gastric lesion.

The authors report 5 such cases, the first of which was erroneously interpreted as an intrinsic gastric lesion because of a constant, concave filling defect along the upper lesser curvature in the region of the cardia. Careful retrospective study disclosed the importance of an easily visualized calcified splenic artery adjacent to such a defect.—*Edward B. Best, M.D.*

HARTZELL, HOMER V., and CHESLEDON, WAYNE A. The amplifying fluoroscope; comparison with conventional fluoroscope in two thousand examinations of the stomach. *J.A.M.A.*, Feb. 15, 1958, *166*, 759–761. (Address: W. A. Chesledon, 306 Stimson Bldg., Seattle, Wash.)

An analysis was done of 1,000 upper gastrointestinal examinations performed before the installation of an image amplifying fluoroscope and a comparison was made with 1,000 examinations performed using the amplifying fluoroscope. There was no essential difference in the diagnoses obtained between the 2 types of fluoroscopes used provided that adequate spot and routine roentgenograms were made. The authors felt more certain of the fluoroscopic findings using the amplifying fluoroscope. The other advantages included decreased radiation, ease and speed of examination and shorter dark adaptation.

The authors fluoroscoped at 2 ma. and 100 kv., with 3 mm. Al filter. Large, heavy patients were found to be much easier to examine.

The reputed disadvantages of small field size and bulkiness were found not to be objectionable.—*Charles W. Cooley, M.D.*

KAUFMAN, S. A., and LEVENE, GEORGE. Postbulbar duodenal ulcer. *Radiology*, Dec., 1957, *69*, 848–852. (Address: S. A. Kaufman, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.)

Peptic ulcer of the duodenum involving the postbulbar region presents important clinical and roentgenologic differences from the usual type of duodenal ulcer. A high incidence of bleeding, and an increased frequency of intractability to treatment, make the prognosis rather poor and demand special therapeutic considerations. Postbulbar ulcers occur with greater frequency than one would expect from published reports and statistics. About 5 per cent of roentgenologically demonstrated duodenal ulcers are located distal to the bulb. Some authors report that 20 per cent of peptic ulcers found at autopsy are postbulbar.

The roentgenologic findings in postbulbar ulcers are characteristic. Duodenal narrowing due to sustained spasm of the wall opposite the ulcer crater is the most constant finding. The ulcer crater is usually well demarcated in the proximal two-thirds of the descending duodenum in the immediate vicinity of the ampulla of Vater. The area adjacent to the ulcer often shows evidence of irritability and the mucosal pattern may be distorted by edema and inflammation. The duodenal bulb shows no constant findings.

A greater awareness of these relatively common lesions should lead to their more frequent diagnosis.—*Arno W. Sommer, M.D.*

FIGIEL, STEVEN J., FIGIEL, LEO S., and RUSH, DESMOND K. Study of colon by use of high-kilovoltage spot-compression technique. *J.A.M.A.*, March, 1958, *166*, 1269–1275. (Address: S. J. Figiel, 4160 John R. St., Detroit 1, Mich.)

Comparison with double contrast, high kilovoltage and postevacuation techniques shows that compression combined with high kilovoltage is best for detection of polypoid lesions. The technical factors, patient preparation, opaque medium and compression cone are discussed.

The amount of radiation exposure was investigated and found to be significantly reduced.

Routine use of this technique revealed numerous asymptomatic polyps, their number and location approaching autopsy data. The incidence of malignancy and management of polypoid lesions are discussed.—*Jack Purcell, M.D.*

WIETERSEN, FRED K., and BALOW, ROSS M. Colonic endometriosis: Roentgenologic aspects. *Radiology*, Dec., 1957, *69*, 839–847. (Address: 18700 Meyers Road, Detroit 35, Mich.)

Involvement of the colon by endometriosis is not an unusual occurrence since approximately one-half of all cases of endometriosis will show intestinal involvement which chiefly affects the rectum and sigmoid in the region of the cul de sac. Clinically, these

patients are usually between thirty and forty years of age. The presenting gastrointestinal symptoms are of long duration and variable but most frequently there is a history of progressive constipation. Painful defecation, cramps and sometimes diarrhea may appear with the menstrual period. Sterility is common and dysmenorrhea is a frequent complaint.

Nine cases of colonic endometriosis are presented in which the authors demonstrate that the colon lesions are of two types, namely, a polypoid lesion involving the wall, and a constricting stenosing lesion producing varying degrees of obstruction. Such lesions, therefore, must be differentiated from carcinoma and inflammatory disease. As distinguishing features, the authors conclude that typically the lesions of colonic endometriosis are short (over 6 cm. in only 2 cases), fixed, nontender between menstrual periods, and both the polypoid and concentric lesions show an intact mucous membrane; there is usually sharp demarcation in the case of a concentric lesion, and obvious involvement of the wall of the bowel if the defect is polypoid. They further suggest that the roentgen findings, when carefully correlated with the clinical picture, will contribute materially to the diagnosis of this disease.—*Edward B. Best, M.D.*

Hodge, Joseph, Barrick, Claude, and McLaughlin, Edward. Biliary dyskinesia in T-tube cholangiography. *A.M.A. Arch. Surg.*, March, 1958, *76*, 361–364. (From: Jefferson Medical College Hospital, Philadelphia, Pa.)

The authors review the etiologic factors for symptoms persisting or following cholecystectomy for gallbladder disease. These include residual calculi in the biliary ducts, stricture of the common duct and surgical factors. Additional unusual factors include recurring pancreatitis, fibrosis or anomalies of the sphincter of Oddi, adhesions, neoplasms of the ampulla of Vater and psychosomatic elements.

The authors report 10 cases that developed biliary dyskinesia following T-tube cholangiography by medopaque H in a series of 36 patients who had such a procedure. Seven of these cases are described in detail with 5 of them showing evidence of pancreatitis and associated chemical colangitis.—*T. D. Allison, M.D.*

McConnell, Fleming. Malignant neoplasm of the gallbladder: Roentgenological diagnosis. *Radiology*, Nov., 1957, *69*, 720–725. (Address: Massachusetts General Hospital, Boston 14, Mass.)

A review of the roentgen findings in 33 cases of histologically proved malignant neoplasms of the gallbladder is presented. Examination of the upper gastrointestinal tract showed, in 18 instances, significant local pressure defects in the distal stomach or adjacent duodenum caused either by the primary tumor or by its local metastases. In 7 instances a mass was demonstrable on plain roentgenograms of the abdomen. In only one of the 14 patients in whom barium examinations of the colon were done was a pressure defect of the colon seen. Contrast studies of the gallbladder in 12 patients revealed only the presence of stones or a nonfunctioning gallbladder.

Roentgenologically, the most frequent and confusing conditions requiring differentiation were carcinoma of the head of the pancreas and hydrops of the gallbladder. While the diagnosis of carcinoma of the gallbladder is difficult, both clinically and roentgenologically, certain fairly typical findings on these roentgen studies may be present and when recognized may lead to a correct diagnosis.—*Donald N. Dysart, M.D.*

Lowman, Robert M., and Davis, Leonard. The role of barium contrast studies in the diagnosis of retroperitoneal tumors. *Radiology*, Nov., 1957, *69*, 641–656. (Address: R. M. Lowman, Grace-New Haven Community Hospital, 789 Howard Ave., New Haven 4, Conn.)

The purpose of this paper is to assay the role of barium contrast studies in the diagnosis of retroperitoneal tumors. These contrast studies, utilized primarily to exclude the presence of intrinsic lesions within the gastrointestinal tract, also provide an appreciation of the presence of unsuspected masses, and delineate abdominal masses known to be present. They are often the pivotal point for outlining subsequent studies. The more precise, direct techniques that can be used, such as retroperitoneal pneumography, aortography, venography, and nephrotomography are suggested by the findings of the indirect, simpler, and less hazardous procedures of plain roentgenography of the abdomen, barium contrast studies and pyelography.

Since tumors originating in the retroperitoneal space may lift any of the abdominal viscera from the posterior wall and may extend into the mesentery of the large or small intestine, pressure patterns are formed which are seen on the gastrointestinal contrast studies. These studies, it must be remembered, may indicate only the size and relative location of a mass, yielding no additional information as to whether the site is intraperitoneal or extraperitoneal.

The authors describe in detail the various patterns formed by retroperitoneal masses in each part of the abdomen. Several roentgenograms are reproduced illustrating some of the findings, and drawings are presented which show the expected displacement of the intestinal tract by other masses.—*Donald N. Dysart, M.D.*

Genitourinary System

Piemonte, Mauro, and Magno, Lorenzo. Sulla eliminazione renale dei mezzi di contrasto iodati. (On the renal elimination of iodine-

containing contrast media.) *Radiol. med.*, March, 1958, *44*, 225–248. (From: Istituto di Radiologia dell'Università di Milano, Divisione Rad. dell'Ist. Naz. per lo Studio e la Cura dei Tumori, Milano, Italy.)

The article gives a comprehensive and detailed analysis of the factors which regulate the elimination through the kidneys of iodine-containing contrast media.

In the first part, after a review of the fundamental principles of renal physiology, particular attention is paid to the glomerular and tubular filtration. An accurate evaluation of "plasma clearance," "depression limit" and "Tm," in relation to the contrast media and their elimination confirms that these are eliminated mainly by glomerular filtration.

The second part deals with the roentgenologic evaluation of the function of the kidneys by means of intravenous urography, and the authors point out that this examination in itself cannot give reliable information on the real condition of the renal parenchyma.

In the last part, the problem of nephrography is discussed in detail. In the authors' opinion a nephrographic effect is observed whenever the concentrated contrast medium is retained in the renal tubules. They distinguish four main types: (1) nephrography from arterial hypotension; (2) nephrography from increased plasmatic pressure; (3) nephrography from increased renal intracapsular pressure; (4) nephrography from tubular inhibition.

Nephrography observed not infrequently in the course of a cholecystographic examination is due either to the excretion of a great quantity of the contrast medium through the kidney, in a limited time, or to the coexistence of this phenomenon with one of the above mentioned causes.—*A. F. Govoni, M.D.*

WOHL, GEORGE T. Use of contrast media in the recognition of hypertension of renal origin. *Radiology*, Nov., 1957, *69*, 672–675. (Address: VA Hospital, Philadelphia 4, Pa.)

Renal hypertension may be divided into two types: (1) that developing secondary to primary renal disease and (2) the much less common type developing as a result of renal circulatory disturbance. The common causes of interference with circulation resulting in renal hypertension are embolism, thrombosis, developmental defect, arteriosclerotic plaques, aneurysm and syphilitic arteritis. A rare form is that resulting from pressure on the major renal artery by extrinsic sources.

In the study of patients suspected of renal hypertension, scout roentgenography, intravenous urography, and retrograde pyelography are routine procedures which will often furnish adequate information. Occasionally, retroperitoneal contrast study with a gaseous medium will be useful in demonstrating the absence of a kidney or showing a small, nonfunctioning organ. Normal renal function and a normal intravenous urogram do not necessarily exclude interference with the circulation. In some instances aortography is required for delineation of the primary circulatory disturbances. Lumbar aortography is a relatively simple procedure, but it should be remembered that serious accidents have occurred.

The author reports a case of hypertension of renal origin in a thirty-six year old male. A survey roentgenogram of the abdomen revealed a small right kidney. On intravenous urographic study there was excellent concentration of the medium in both kidneys, and the pelvicalyceal system appeared normal roentgenographically. Aortography demonstrated an accessory right renal artery, but no main right renal artery was visualized. At operation a ruptured right renal aneurysm with a false aneurysmal sac filled with laminated clot was found. The blood pressure returned to normal after removal of the kidney, and has remained at a normal level for three years.—*Arno W. Sommer, M.D.*

WEINER, MARVIN E., ALCORN, FRANKLIN S., and JENKINSON, EDWARD L. Subcapsular rupture of the kidney during intravenous urography. *Radiology*, Dec., 1957, *69*, 853–855. (Address: M. E. Weiner, St. Luke's Hospital, Chicago 5, Ill.)

The authors present a case believed to be the first reported example of subcapsular reflux occurring secondary to rupture of the renal sinuses. The occurrence of this finding was thought to be due to the use of external compression which caused sufficient retrograde pressure to produce rupture of the collecting system near its origin and permitted the contrast medium to extravasate into the subcapsular space. No ill effects were suffered by the patient.

The relatively more common types of extravasation of medium are briefly discussed.—*Donald N. Dysart, M.D.*

EVANS, JOHN A. Nephrotomography in the investigation of renal masses. *Radiology*, Nov., 1957, *69*, 684–689. (Address: The New York Hospital, 525 E. 68th St., New York 21, N. Y.)

The author describes a procedure called nephrotomography and reports his experience with the use of this method in the investigation of renal masses. Its greatest value lies in its ability to demonstrate whether an intrarenal mass is a cyst or neoplasm. It is a combination of rapid intravenous nephrography and laminagraphy. An analysis of 272 consecutive nephrotomographic studies is presented. A specific diagnosis was made in 252 cases; 20 studies were inadequate technically. Ninety-three studies were interpreted as showing normal kidneys. In this group there were 4 errors. Neoplasms were diagnosed in 44 cases, with 3 errors. In 115 cases a diagnosis of non-

neoplastic cyst was made. Forty-three of these were proved at operation, but there was reasonably conclusive evidence of the correctness of the diagnosis of cyst in 80 cases. No serious reactions and no deaths occurred in this series.

In the nephrotomogram, cysts appear as round, sharply marginated defects in the opacified renal parenchyma. These well-circumscribed areas of radiolucency present an easily recognized and constant pattern. Solid tumors of the kidney present an opaque appearance of equal or greater density than the adjacent normal parenchyma. In the arterial phase of the examination, an abnormal vascular bed may be identified; if present, it indicates a solid mass rather than an avascular cyst.—*Arno W. Sommer, M.D.*

Caine, Marco, and Edwards, David. The peripheral control of micturition: A cineradiographic study. *Brit. J. Urol.*, March, 1958, *30*, 34–42. (From: The Institute of Urology, University of London, London, England.)

The authors point out that the development of the roentgen-ray image intensifier has afforded the opportunity for a fresh approach to the investigation of many of the dynamic functions of the human body. It consists essentially of a method of amplifying, by means of an electronic accelerator, an extremely weak roentgen-ray image produced by a very small screening current, with the resultant production of a small but brilliantly illuminated image. This image can be viewed through an optical system by the naked eye or can be photographed by a camera.

Using this image intensifier, the authors give a report of an investigation into the peripheral control of micturition. The technique used is detailed and the scope of their investigation is defined.

The appearance in the normal subject is described and special attention is drawn to a feature termed reflux emptying of the posterior urethra seen on the voluntary cessation of micturition.

The control after prostatectomy is seen to be strictly comparable with the normal. In particular, the reflux emptying still takes place from the external sphincter, either to the prostatic cavity or to the neck of the bladder. It is stressed that the lower extremity of the resting column of urine in the bladder neck is inconsistent and since a prostatic fossa remains, is at the lower extremity of the prostatic fossa, and not at the external sphincter—as usually stated.

The concept of a dual mechanism in normal continence is proposed, and the components are designated "active continence" and "passive continence." The functions and mechanisms of each of these are suggested.

Examination of cases of postprostatectomy incontinence showed an absence of reflux emptying, and this was correlated with the concept of active and passive continence. Bilateral pudendal nerve block after prostatectomy was found not to produce incontinence, thus supporting the contention that the external sphincter is not the structure maintaining passive continence in the postprostatectomy subject.

The authors hope that this investigation helps to define the nature of the peripheral mechanism of continence after prostatectomy, and to establish the exact location of the damage in the patient with postprostatectomy incontinence. It is submitted that there is roentgenologic, clinical, and experimental evidence in support of the concept of "active continence" and "passive continence," and that the use of this concept in the future should aid to clarify the approach to problems arising in the control of micturition and its impairment.

The paper is well illustrated with photographs and drawings.—*Robert D. Moreton, M.D.*

Van Woert, Irving, Jr., Kearney, Paul I., Kilicozlu, Ilhan, and Roach, John F. Radiation hazards of intravenous pyelography. *J.A.M.A.*, April 12, 1958, *166*, 1826–1828. (From: The Department of Radiology, The Albany Medical College and Albany Hospital, Albany, N. Y.)

The authors point out that recent work has indicated the possibility that young patients (children and young adults) are receiving radiation to their gonadal regions during the course of diagnostic roentgen examinations, which might have undesirable effects on the future offspring and that intravenous pyelography is perhaps one of the most dangerous methods from the point of view of gonadal injury.

Intravenous pyelography was selected as a basis of study to establish stricter criteria as indications for the procedure, the determination of gonadal dosage received during pyelography, and a consideration of the practicality of providing physical protection to gonadal areas.

The study consisted of a review of records of 200 consecutive hospital and clinic patients who had undergone intravenous pyelography in the radiology department. Fifty-five of these patients were interpreted by the radiologist as having pathology of the urinary tract. It became evident that the presence of the pathology could not have been accurately predicted by a simple analysis of the clinical signs, symptoms, and laboratory findings. The authors suggest a list of indications for intravenous pyelography which is actually a modification of several lists that have appeared in the literature and in various textbooks.

In the measurement of the gonadal exposure, the quality of the irradiation used was soft, 65–100 kvp. range, but was hardened by the use of 3 mm. of aluminum filter. The dose to the testes varied from

0.1 to 4 r in the male. In the female, it ranged from 0.2 to 0.5 r.

The authors suggest methods of decreasing the gonadal radiation, such as collimation of the beam, use of aluminum filters, and the protection of the gonads by lead rubber or a small lead shield in the male. They noted from studies of involvement of the lower portion of the ureters that practically all findings could be detected on the fifteen minute roentgenogram. It is recommended that for the five and ten minute roentgenograms the ovarian regions be protected with a lead shield, the upper edge of which is at the level of the iliac crest.—*Robert D. Moreton, M.D.*

GIRAUD, M., BRET, P., KUENTZ, M., ANJOU, A., COSTAZ, G., and CHOLLAT, L. (Lyon, France.) Étude radiologique et stratigraphique des tumeurs surrénaliennes; à propos de 11 observations, dont 3 formes bilatérales. (Radiologic and stratigraphic study of adrenal tumors; report of 11 cases, 3 of which showed bilateral involvement.) *J. de radiol., d'électrol. et de méd. nucléaire*, Sept.–Oct., 1957, *38*, 893–904.

During a four year period, the authors examined 100 patients with laminagraphy following retroperitoneal air insufflation. In some cases intravenous urography was performed simultaneously. Eleven cases of adrenal tumors were discovered, of which 3 had bilateral involvement.

The prevalent findings in the patients examined were abnormal pubic hair distribution, hypertrophy of the clitoris and obesity. Four patients manifested endocrine disturbances, 4 had arterial hypertension and 2 complained of lumbar pain. A tumor mass was palpable in the right or left hypochondrium.

The roentgenologic examination included: (1) Plain roentgenography which often revealed the presence of a tumor mass; (2) intravenous urography which at times showed depression of the kidney under the tumor mass, with or without compression and deformity of one of the calices; and (3) retroperitoneal air injection which often adequately outlined the tumor mass. However, laminagraphy was found to be of great aid in providing better delineation and definition. Frontal sections were made beginning at a depth of 6–7 cm. from the skin surface of the back in 1 cm. layers, up to a depth of 10–12 cm. Additional sections—transverse or saggital—may be necessary.

The roentgenologic study should aim at establishing the presence of the tumor, its uni- or bilaterality, its exact relation to the adrenals, superior pole of the kidney (to rule out a cyst of the upper pole of the kidney), aorta, vena cava, and in the case of a very large tumor, the kidney and spleen.

Fourteen reproductions of roentgenograms and diagrams accompany this excellent article.—*William H. Shehadi, M.D.*

STEINBACH, HOWARD L., HINMAN, FRANK, JR., and FORSHAM, PETER H. The diagnosis of adrenal neoplasms by contrast media. *Radiology*, Nov., 1957, *69*, 664–671. (Address: H. L. Steinbach, University of California Medical Center, San Francisco 22, Calif.)

Plain roentgenography and laminagraphy will sometimes demonstrate normal as well as enlarged adrenal glands, but frequently other diagnostic procedures are required. Aortography and urography are sometimes of value. Extraperitoneal pneumography with laminagraphy is the most useful roentgen procedure for identification of cortical hyperplasia, unilateral benign or malignant tumors, and cortical atrophy of the adrenals. In the absence of clinical or laboratory evidence of altered secretion, the size of the glands is of no significance; it must be correlated with body weight or surface area. As a rule, the larger glands secrete more hormone, but occasionally glands of normal size in patients with Cushing's syndrome are capable of excessive secretion.

Adrenal cortical adenomas may or may not be associated with endocrine disturbances. The nonfunctioning tumors are frequently very large when discovered. Functioning cortical adenomas may produce clinical evidence of Cushing's syndrome or they may produce the adrenogenital syndrome.

Adrenal cortical adenocarcinoma, if it remains confined to the gland, may present the same appearance on the roentgenogram as a benign tumor. As the lesion enlarges or invades the surrounding tissues, it may compress or invade the periadrenal areolar tissue and prevent the passage of gas into the adrenal area. Functioning cortical adenomas and adenocarcinomas in patients with Cushing's syndrome are usually accompanied by atrophy of the contralateral adrenal. In cases of cortical adenoma or adenocarcinoma with adenogenital syndrome, the opposite gland is of normal size when there is no associated excess of 17-hydroxycorticoid. Pheochromocytomas of the adrenal gland appear similar to adrenal cortical tumors. Bilateral small adrenals may indicate the presence of a functioning adrenal cortical tumor in an extra-adrenal site.—*Arno W. Sommer, M.D.*

NÄGELE, E. Röntgenbefunde bei Alkaptonurie. (Roentgen findings in alkaptonuria.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Oct., 1957, *87*, 523–529. (Address: Eduard Nägele, Röntgenabteilung der Med. Univ.-Poliklinik, Giessen-Lahn, Germany.)

This hereditary disturbance of metabolism produces roentgen changes due to cartilage degeneration in weight-bearing joints and the spine.

The roentgen changes are: generalized narrowing of disk spaces and calcium deposits in the disks, sclerosis and irregular contour of the adjacent verte-

bral surfaces, osteoporosis and osteoarthrosis deformans of the spine and large joints and calcium deposits in tendons, synovial membranes, longitudinal ligaments of the spine and ear cartilages. Eye changes and prostatic concretions are less common findings.

The author discusses the cases of 2 brothers.—*Frederick M. Reis, M.D.*

Nervous System

Grosjean, M. À propos de l'emploi du pantopaque dans les myélographies. (On the use of pantopaque in myelographies.) *J. de radiol., d'électrol. et de méd. nucléaire*, Nov.–Dec., 1957, *38*, 1053–1061. (From: Institut de Radiologie de l'Université de Zurich, Zurich, Switzerland.)

The study of 234 case reports of the University Departments of Neurosurgery and Neurology shows that it is rare that clinical investigation alone provides precise information on the seat and nature of the lesion, and that roentgenologic examination has to complete the diagnosis. When compared to the results and dangers of lipiodol, pantopaque appears to be a product easier to handle and less dangerous than its predecessor. Nevertheless since its stability over the long term is not yet proved, and it may give rise to allergic reactions in hypersensitive patients, it should be handled with prudence and its indications remain strict.

A myelography is not performed if a lumbar puncture has been done in the preceding week, since there may be a subdural collection of spinal fluid, causing false placement of the pantopaque.

After the study, firm efforts are made to remove the opaque medium. If the needle point is obstructed, apparently by a nerve root, another lumbar puncture is done at a lower level. If the oil cannot be removed because it is fragmented in droplets or because the arachnoid is collapsed from the removal of a large amount of spinal fluid, a second lumbar puncture is done several days later.—*Frank A. Riebel, M.D.*

Skeletal System

Reinhardt, K. Le glissement vertébral par rotation et son importance en clinique. (Rotational vertebral gliding and its clinical importance.) *J. de radiol., d'électrol. et de méd. nucléaire*, Sept.–Oct., 1957, *38*, 905–915. (From: Institut central de Radiologie de l'Université, Homburg, Sarre.)

The author indicates that the lumbosciatic and painful shoulder syndromes are, for the most part, caused by mechanical alterations of the vertebral column; consequently the question arises as to whether other diseases affecting organs of the chest and abdomen, may not be the result of vertebral alterations. Furthermore, the question arises as to whether such affections may not be curable through manipulation of the spine. From an etiologic point of view, disk herniation seems a less likely cause than displacement of one or more vertebral segments.

The author speaks of rotational gliding or sliding of a vertebra, with the rotation occurring at the apophyseal articulations. The vertebral body appears to slide or glide "away," and a concomitant scoliotic deformity occurs.

Eighty-eight cases are reviewed. In 81 per cent gliding was combined with scoliosis. The latter is rarely congenital and should be considered a sequela to gliding.

The causes of primary gliding are to be found in diminished solidity of the intervertebral disk, developmental anomalies, and degeneration due to inflammatory or neoplastic disease. The average age of the patients examined was sixty-one years. Sixty-nine were males and eleven were females.

Lumbar spine rotation was at an anterior or ventral axis, while in the dorsal spine, because of the formation of the apophyseal joints, the rotation occurred along a dorsal axis.

Twenty-eight sketches, diagrams and reproductions of roentgenograms accompany this article.—*William H. Shehadi, M.D.*

Schwarz, Gerhart S. Bilateral antecubital ossicles (fabellae cubiti) and other rare accessory bones of the elbow; with a case report. *Radiology*, Nov., 1957, *69*, 730–734. (Address: The Presbyterian Hospital, 622 W. 168th St., New York 32, N. Y.)

Accessory ossicles about the elbow joint are rare. A correct roentgen diagnosis is often difficult to make because of the variety of bones that may occur in this area. These include the following: (1) an articulated olecranon spur; (2) calcareous bursitis dorsal to the biceps tendon; (3) loose bodies secondary to osteochondritis dissecans; (4) accessory coronoid ossicle; (5) ununited olecranon epiphysis; (6) antecubital bone; (7) ununited medial and lateral epicondyles of the humerus; and (8) traumatic fracture fragments.

The author presents a case of bilateral antecubital bones which he calls "fabellae cubiti," associated with a unilateral accessory coronoid ossicle and a unilateral paratrochlear bone. Zimmer had previously described the persistent ossification center of the coronoid and called it the "os cubiti anterior." The author disputes this terminology on the basis of the findings in his case, *i.e.* the simultaneous existence of the accessory coronoid ossicle with a true antecubital bone, proving that these 2 conditions are not identical. This appears to be the first example of antecubital bones diagnosed during life.—*Z. Petrany, M.D.*

Fineman, Sol. Newer methods for symmetrical roentgenography of the intervertebral foramina of the cervical spine and optic foramina.

Radiology, Nov., 1957, *69*, 739–744. (Address: 133 East 58th Street, New York 22, N. Y.)

Good visualization of the intervertebral foramina is essential in the diagnosis of pathologic conditions which constrict and distort the foramina, creating the variety of symptoms that are associated with pressure on the cervical nerve roots. The author presents an ingenious method for consistently obtaining symmetrical views of the intervertebral foramina of the cervical spine. A chair is fixed on a circular board to which a circular protractor is mounted. This circular board in turn is swivelled on a square board base and the angles indicated on the protractor extend to the edge of the circular board and on to the base. This makes it possible to rotate the patient an exact number of degrees in either direction. A head clamp is attached to the back of the chair so that the head may be immobilized. Thus, the patient may be rotated exactly 45, 90, and 180 degrees and consistently good symmetrical oblique and lateral views obtained. This equipment is also adaptable for good visualization of the optic canals. As the optic canals point approximately 38 degrees laterally and 38 degrees downward from their origin in the lesser wings of the sphenoid bones, this technique is extremely valuable in correctly positioning the patient for roentgenography.—*John Alexander, M.D.*

PIRKEY, EVERETT L., and PURCELL, JACK H. Agenesis of lumbosacral vertebrae; a report of two cases in living infants. *Radiology*, Nov., 1957, *69*, 726–729. (Address: E. L. Pirkey, School of Medicine, University of Louisville, Louisville 2, Ky.)

The report deals with congenital anomalies of the spine with a brief discussion of the embryology and a review of some of the pertinent literature.

The authors describe 2 of their own cases, one of which was a nine month old male infant, with a negative family and normal pregnancy history. The entire lower extremities were underdeveloped and were flexive and there was clubbing of both feet. The hip joints were in abduction and the knee joints were flexed, with webbing of the skin over these joints. Roentgenograms showed complete absence of all lumbar, sacral and coccygeal vertebrae. The ilia were fused posteriorly; the acetabular components were deformed and there was widening of the symphysis pubis. The normal muscle density of the thigh and legs was replaced by fat density.

The second case was similar, differing in that it was a premature infant, had hydrocephalus and died on the fifth postnatal day. A number of etiologic factors are listed, including syphilis, poor nutrition, heredity, endocrine disorders, intrauterine inflammation and severe illness. No definite extrinsic factors could be found in either of the 2 cases presented.—*Z. Petrany, M.D.*

SCHNEIDER, CHESTER C., and MELAMED, ABRAHAM. Spondylolysis and spondylolisthesis; case report clarifying the etiology of spondylolysis. *Radiology*, Dec., 1957, *69*, 863–866. (Address: C. C. Schneider, 620 North 19th Street, Milwaukee 3, Wis.)

The authors present an unusual and interesting case of spondylolysis with spondylolisthesis, with perhaps the first recorded instance of serial roentgenograms which demonstrate the development of the process.

The case is that of a male patient who, at age one year, fell down a flight of stairs but sustained no apparent injury. At age one year six months he experienced stiffness of the lower back. Roentgenograms made at that time, in the anteroposterior and lateral views, disclosed only slight narrowing and irregularity at the L-3 interspace. Follow-up roentgenographic examination at age five years four months showed no essential change, but subsequent study at age eight years six months revealed spondylolisthesis at the lumbosacral junction. Growth at the L-3 interspace appeared arrested. Further study at age fifteen years three months disclosed increased forward displacement of L-5 on the sacrum and wider gaps in the interarticular septa. The third lumbar intervertebral disk was almost obliterated.

Spinal fusion was performed several years later after which his spinal architecture remained static.

The authors propose that the bone defects of spondylolysis are the direct result of trauma to structurally inadequate isthmi, usually within the first two decades of life.—*Edward B. Best, M.D.*

EISEMANN, GUSTAVE, RUBIN, SIDNEY, and DANN, DAVID S. Early clinical and x-ray diagnosis of multiple myeloma. *G.P.*, March, 1958, *17*, 74–76. (From: Section of Hematology and Department of Radiology, Menorah Medical Center, Kansas City, Mo.)

The authors report their experience with multiple myeloma cases over the last ten years. The clinical diagnostic aid in these cases include: (1) Presence of anemia which is normochromic and normocytic; (2) rouleau formation in the blood smear; (3) plasmoblasts; (4) elevated serum protein with a marked increase in the serum globulin; (5) abnormal electrophoresis pattern; (6) occasionally Bence-Jones proteinuria; and (7) hypercalcemia. Positive diagnosis is established by sternal marrow biopsy or direct aspiration of one of the bone lesions.

In the roentgen surveys of these patients, diagnosis was often difficult to pin-point because the typical multiple punched out areas were rarely seen. The authors felt that serial roentgenograms with evident bone changes were most important. Compression fractures were common after minor trauma. The differential diagnosis included osteoporosis, hyperpara-

thyroidism and metastatic bone disease, as well as the usual lytic lesions from metastases, from malignant lesions of the prostate, kidney, breast, ovary and thyroid.—*T. D. Allison, M.D.*

Fischgold, H., Juster, M., and Écoiffier, J. Exploration microradiographique de métastases osseuses épiglandulaires. (Microradiographic study of epiglandular osseous metastases.) *J. de radiol., d'électrol. et de méd. nucléaire*, Nov.–Dec., 1957, *38*, 1069–1076. (From: Laboratoire de la radiographie à haute définition, rue Gay-Lussac 41, Paris, France.)

A case of osseous metastases is studied serially beginning with clinical roentgenography of the living subject through techniques using various degrees of magnification until a roentgenogram of a slice of excised tissue 0.16 mm. thick is produced which reveals the Haversian canal system. Technical factors used for the latter were a Varay tube with an iron anode and beryllium window, tissue in contact with Maximum Resolution Kodak film, and a 50× magnification of the latter.

The authors urge that the search be continued for equipment and techniques which will permit such studies in the living subject. This means the recording of very thin sections, diminution in film grain, better screens, and tubes with focal spots smaller than 0.3 mm. in diameter. Thus microradiography could take a place of importance comparable to that of radiocinematography.—*Frank A. Riebel, M.D.*

DeVries, Paul H., Badgley, Carl E., and Hartman, J. Ted. (Ann Arbor, Mich.) Radiation sterilization of homogenous-bone transplants utilizing radioactive cobalt. *J. Bone & Joint Surg.*, Jan., 1958, *40-A*, 187–202.

Bone-bank stocks to be used for transplants must be sterile and preserved by a method which does not cause appreciable structural or physiologic alterations so that revascularization, absorption and replacement by the host occurs with the minimum of reaction.

While the method of obtaining bone at autopsy, followed by processing and freeze-drying all under sterile conditions is excellent, there are technical difficulties, and freeze-drying does not destroy bacteria or viral organisms. Postoperative infections occurred too frequently following boiling or autoclaving which also causes denaturation of proteins leading to delay in vascularization.

The preservation of food by large doses of gamma radiation which inactivate bacteria and viruses suggested a similar method for the sterilization of bone. The minimum bactericidal dose is 2 million rep and for the inactivation of viruses a dose of 4 million rep is required. Bone from the iliac crests, known to be free of infection or neoplasia, is cut to size, washed, freeze-dried with dry ice and alcohol and dehydrated *in vacuo*. The bone, sealed in Pyrex tubes, is then irradiated to 4 million rep by a Co^{60} source and may then be stored at room temperature.

The use of bone prepared by this method is reported in 104 operative procedures of which 76 were spinal fusions. Positive bone cultures, all of common throat or skin types, occurred in 7 cases and 5 wound infections, mainly a coagulase-positive *Staphylococcus aureus;* 13 such cases are reported in detail. The effect of irradiation and the progress of transplants are shown by photomicrographs and roentgenograms illustrate the value of transplants in enhancing healing following poor union.—*Raymond S. Quick, B.S.*

Blood and Lymph System

Evans, Arthur T. Renal cancer: Translumbar arteriography for its recognition. *Radiology*, Nov., 1957, *69*, 657–663. (Address: 1908 Union Central Bldg., Cincinnati 2, Ohio.)

Translumbar arteriography has been utilized on the urologic service of the Christ and Cincinnati General Hospitals for the past seven years. Over 2,500 aortic punctures have been performed with nothing more serious than minimal morbidity. The following rules are recommended for maximum safety: (a) injection of not more than 15 cc. of contrast medium in one dose, and that only once in twenty-four hours; (b) only one puncture of the aorta at a time, with a needle no larger than 18-gauge; (c) the use of an iodide compound of the type used for intravenous urography; and (d) injection of the aorta above the celiac plexus.

The author considers arteriography the most refined diagnostic method available to the urologist and roentgenologist for the recognition and differentiation of renal cysts and tumors. His reported series of cysts and tumors of the renal parenchyma comprises 236 cases in which arteriography was employed as a diagnostic procedure. According to the diagnosis obtained by arteriographic study, there were 126 tumors and 108 cysts. All but 2 of the patients with a diagnosis of renal tumors were operated upon. The diagnosis of tumor established by arteriography was confirmed by microscopic examination in 120 subjects, an accuracy of 95.2 per cent. In the 82 proved cases diagnosed as solitary renal cyst the accuracy was 96.3 per cent; 3 cases proved to be cancer.

The arterial pattern of a cyst within the kidney is one in which vascularity is lacking. Renal cysts are avascular, but extrarenal vessels may traverse the cystic area of the kidney and lead to confusion. All renal arteries must be traced to their origin. It is often the degree of vascularity and not the absence or presence of vessels that identifies a renal cyst.

The viable portions of renal-cell carcinomas are always quite vascular microscopically. When seen on an arteriogram, this increased vascularity in a por-

tion of a kidney is pathognomonic of renal neoplasms. There is an increase in vessel number as well as in vessel caliber. The second feature of the arterial pattern of renal parenchymal cancer is the irregular vascular caliber, and the bizarre vascular pattern. At times necrosis of a large renal-cell neoplasm may distort the pathognomonic characteristics of the renal arteriogram. This aberration may lead to a false impression of the presence of an avascular area and therefore to a diagnosis of cyst.

Translumbar arteriography is recommended as a simple, safe and worthwhile diagnostic procedure.—*Arno W. Sommer, M.D.*

WYATT, GEORGE M., and FELSON, BENJAMIN. Aortic thrombosis as a cause of hypertension: An arteriographic study. *Radiology*, Nov., 1957, *69*, 676–683. (Address: Department of Radiology, Cincinnati General Hospital, Cincinnati, Ohio.)

It has been proved by animal experimentation that partial interruption of the blood flow to a kidney will cause hypertension. In this paper the authors present 3 case reports of patients who developed a rather sudden severe hypertension following upward extension of an abdominal aortic thrombosis with partial obstruction of a renal artery. In each of these patients, abdominal arteriograms were available before and after the development of hypertension. They vividly portrayed the changes presumably responsible for the blood pressure elevation. In each instance, surgical removal of the compromised kidney resulted in relief of this severe hypertension.

Several roentgenograms are reproduced which illustrate the findings seen on the aortograms.—*Donald N. Dysart, M.D.*

GENERAL

HELLSTRÖM, JOHN, BIRKE, GUNNAR, and EDVALL, C. A. Hypertension in hyperparathyroidism. *Brit. J. Urol.*, March, 1958, *30*, 13–24. (From: The Department of Surgery, Karolinska Sjukhuset, Stockholm, Sweden.)

The authors state that in earlier papers the diagnostic problems and the occurrence of renal calcification and true calculi were discussed. The urologic significance of renal calcium deposits in hyperparathyroidism is demonstrated by the fact that in a series of 105 cases roentgenologically discernible renal calcification was present in 84 per cent, and 52 patients underwent a total of 103 operations for renal calculi. Almost all cases exhibited signs of renal functional disturbance. Such disturbance may be observed even in roentgenologically negative cases, and the renal damage may persist or even progress after a successful parathyroidectomy. Of particular interest is that the hypertension frequently found in hyperparathyroidism may show the same behavior after operation, and in some cases eventually result in a fatal outcome due to cerebral hemorrhage or cardiac insufficiency. An analysis of this series with special reference to the occurrence of hypertension in relation to parathyroidectomy, as well as its possible relation to the renal lesion, was made by the authors.

They point out that there are few references to hypertension in papers on hyperparathyroidism. Some investigators hold that the blood pressure is generally normal, while others found hypertension in advanced stages of the disease, and cerebral vascular accidents often appear among the recorded causes of death.

The authors found no systematic study of the blood pressure in previous literature on hyperparathyroidism. They, therefore, made an analysis of their present series in this respect, supplemented by a study of the renal function as measured by clearance methods, concentration tests, and examination of renal biopsies obtained by percutaneous puncture or at operations for renal calculi.

In a series comprising 105 cases of hyperparathyroidism, 95 were successfully parathyroidectomized and have been satisfactorily followed up. The principal aim of the investigation was to establish the incidence of hypertension in hyperparathyroidism and to find out if there was any correlation between the renal damage and the occurrence of hypertension. The possibility of a relationship between other symptoms of hyperparathyroidism and hypertension was of interest, and the behavior of the blood pressure and renal function following parathyroidectomy was studied. It was found that 70 per cent of the cases had hypertension some time during the observation period, the distribution being as follows: 50 per cent constant hypertension; 20 per cent hypertension before, with normal blood pressure after parathyroidectomy; and 30 per cent developing hypertension after parathyroidectomy.

It was noted that the presence of renal calculi or severe renal infection was not demonstrably related to hypertension. Nephrolithiasis seemed to be the predominating finding in the normotensive group. If there was any correlation between nephrocalcinosis and hypertension existing at all, it was a slight one. The patients with parathyroid osteitis were encountered mainly in the hypertensive group and were infrequent in the normotensive group and the group with postoperatively normalized blood pressures.

The mortality was 20 per cent (21 cases). The causes of death were azotemia in 11 cases, sequelae of hypertension (cerebral vascular accidents and cardiac failure) in 8, and suicide and arteriosclerosis in one each.

A striking correlation was found between the extent of renal damage (found by functional studies and routine biopsies) and the severity of hypertension. The results also indicate that the impairment

of renal function preceded the development of hypertension, which implies that the hypertension of hyperparathyroidism may be of renal origin.

The actual mechanism producing these manifestations was not clear from the findings in the present investigation. The authors conclude that further studies are necessary.

The paper is well illustrated by multiple charts indicating the pertinent findings in each of the groups investigated.—*Robert D. Moreton, M.D.*

Buice, James W., and Gould, David M. Abdominal and pelvic pneumography. *Radiology*, Nov., 1957, *69*, 704–710. (Address: D. M. Gould, University of Arkansas Medical Center, Little Rock, Ark.)

The diagnostic potential of pneumoperitoneum has never been realized, primarily because of the minor complications experienced with slowly absorbed gasses. Nitrous oxide is an excellent gas for such a procedure for, in comparing relative solubilities in water at 37° C., nitrous oxide is 18 times more soluble than oxygen and only slightly less soluble than carbon dioxide, the gas now most widely used for diagnostic purposes. Although the authors prefer the transabdominal insufflation route in all patients, cul-de-sac puncture or the transuterine route may be used in females. Following insufflation, the area to be studied is placed uppermost with pelvic lesions being delineated best in a 45° Trendelenburg position. The procedure can be done on an out-patient basis and seldom requires more than fifteen minutes.

The failure of routine examinations to clearly demonstrate a disease process is sufficient indication for diagnostic pneumoperitoneum. It is particularly useful in demonstrating abnormalities of the pelvic viscera and, with proper positioning, many alterations in the upper abdomen can be visualized. Since the use of nitrous oxide is safe and free of side-effects, the authors no longer agree with the concept that diminished cardiac reserve, large abdominal or pelvic masses, or pelvic inflammatory disease preclude diagnostic pneumoperitoneum—except in critical cases. In a series of 110 patients, varying in age from twenty-nine days to seventy-two years, no untoward reactions were encountered.—*Edward B. Best, M.D.*

RADIATION THERAPY

Friedman, Milton, and Schwartz, Emanuel E. Irradiation therapy of pigmented villonodular synovitis. *Bull. Hosp. Joint Dis.*, April, 1957, *18*, 19–32. (From: The Lila Motley Radiation Therapy Department, Hospital for Joint Diseases, New York 35, N. Y.)

Pigmented villonodular synovitis, as a primary lesion, is most commonly found in young adults. The disease is insidious in its course, starting with swelling, tenderness and impaired motion of the joint, most commonly the knee. The diagnosis is usually based on a swollen joint, aspiration of blood-tinged fluid or brownish hemosiderin from the joint space, roentgenographic evidence of thickened synovium with occasional nodular masses, and microscopic examination of a biopsy specimen or incompletely removed synovium. Other diseases, such as degenerative arthritis or traumatic degeneration of a meniscus, may occasionally evoke a secondary proliferative synovitis resembling pigmented villonodular synovitis. One less common form of pigmented villonodular synovitis is associated with tendon sheath and invades adjacent bone.

The authors report 10 cases of pigmented villonodular synovitis of the knee joint treated by radiation therapy including 2 cases reported previously by one author (M. F.). Nearly all cases had some form of surgery, partial or subtotal synovectomy, prior to irradiation. Two cases were considered radiation failures and both were atypical in that pigmented villonodular synovitis was superimposed on a more serious underlying disease and should be considered as secondary lesions. The duration of follow-up on the 8 successfully treated cases extends from three months to fifteen years.

Reference is also made to an additional 9 cases found in the literature involving the knee and other major joints, which had responded favorably to irradiation.

The authors suggest that irradiation may be the treatment of choice in primary pigmented villonodular synovitis uncomplicated by underlying pathology of adjacent bones. A tissue dose of 2,000 to 3,000 r is considered to be adequate. The reason for its radiosensitivity is not yet known. Their impression is that the parent cell is the local tissue histocyte and this is radiosensitive.—*A. Hatam, M.D.*

Brunschwig, Alexander, and Daniel, William. The surgical treatment of cancer of the cervix uteri. *Am. J. Obst. & Gynec.*, April, 1958, *75*, 875–881. (From: Memorial Center for Cancer and Allied Diseases, New York, N. Y.)

Between 1952 and 1957, 461 patients with previously untreated carcinoma of the cervix were registered on the Gynecological Service of the Memorial Center for Cancer and Allied Diseases, New York. These were to form the basis of a series of consecutive cases treated by surgery alone.

Of the total, 348 had surgery in an attempt to cure, consisting mostly of radical hysterectomy with pelvic lymph node dissection. Ninety seven in the surgical group had received preoperative irradiation, often as a temporizing measure until a bed could be obtained.

The five year survival in the surgical group was 55 per cent, ranging from 79 per cent for Stage I lesions (none *in situ*) to 19 per cent for Stage IV. Most

of the remaining 113 patients either refused treatment or were given radiation therapy. In the latter group were 26 (6.3 per cent of 461) who were not considered suitable for surgical treatment.

Those with involved pelvic lymph nodes showed shorter survival than those without; thus, Stage I lesions in which no involved lymph nodes were found had an 82 per cent five year survival, whereas the Stage I lesions with such lymph nodes had a 61 per cent survival.

The surgical mortality (death in thirty days) was 1.15 per cent. There were 45 urinary tract fistulae for an incidence of 13 per cent.

The authors conclude that no categorical statement can be made as to whether radiation therapy or modern surgery is the better primary treatment for cancer of the cervix, but they consider this article as a progress report on what modern surgery alone can do.—*H. J. Klos, M.D.*

STEVENSON, CHARLES S. The treatment of carcinoma of the cervix with full irradiation therapy followed by radical pelvic surgery; first progress report on an experimental series. *Am. J. Obst. & Gynec.*, April, 1958, *75*, 888–898. (Address: 1401 Rivard Street, Detroit 7, Mich.)

An experimental series utilizing full preoperative radiation therapy followed by a Wertheim-Bonney hysterectomy was begun at Detroit Receiving Hospital in 1949.

A total of 195 patients were seen, of which 52 were considered suitable for surgery. The surgical cases included 7 patients in Stage III but none in Stage IV. Each patient received external deep roentgen therapy and intracavitary radium therapy, usually with the Ernst applicator. Surgery followed in from twelve to sixteen weeks unless the lesion did not seem to be controlled by the irradiation in which case surgery was performed sooner.

In the surgical specimens removed, residual carcinoma was found in 18 cases or 34.6 per cent. These were in 12 cervices, 2 uteri, 2 cardinal ligaments and in 6 cases in the pelvic lymph nodes, usually the obturator group.

Surgical mortality was not present. There were 5 vagino-urinary tract fistulae for an incidence of 9.6 per cent. Twelve patients have survived five years thus far and 5 have died.

The author concedes that 52 cases are not sufficient to permit statistical analysis.—*H. J. Klos, M.D.*

SCHOEN, D. Klinische Betrachtungen über Entstehung und Behandlung der Bestrahlungsleukopenie. (Clinical considerations regarding the cause and treatment of radiation leukopenia.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Jan., 1958, *88*, 12–24. (From: Medizinisches Strahleninstitut der Universität, Tübingen, Germany.)

This report is concerned with 461 patients treated with stationary deep roentgen therapy in conventional range (200 to 220 kv.), high voltage roentgen therapy (15.8 mev.), and accelerated electrons (5 to 15 mev.). The studies were not concerned with the leukopenia which takes place about twenty-four hours after the initiation of the therapy, but with the later phase which ensues five to six days after treatment was started. The blood picture was considered as leukopenic when it dropped to 3,000 white cells per 1 mm.^{3} The blood cell count was repeated at intervals of five to ten days and in pathologic cases more frequently.

The percentage of leukopenic cases was clearly dependent upon the treated area. Of 152 cases treated over the abdomen, 44 per cent had leukopenia. Of 231 cases with treatment over the thorax, 28 per cent developed leukopenia. Of those treated over the head and neck (65 cases) 8 per cent developed leukopenia and none of those treated over the extremities. In the abdominal portals the inclusion of spleen and liver in the beam is considered an important causative factor in the development of leukopenia. In leukopenia after treatment of mammary cancer there is a difference between the right and left side because of inclusion of either the liver or the spleen in the beam. Thirty per cent of those treated on the right side and 40 per cent of those treated on the left side developed leukopenia. Integral doses, especially the so-called specific integral dose which is a ratio of the integral dose to the body weight with inclusion of the backscatter, have been investigated by Kohn. Gloor and Zuppinger found the protracted radiation method as having less effect on the white blood cell count. Previous irradiation appears to cause increased sensitivity for the future development of leukopenia, due to the cumulative effect. The leukopenic reaction lasts two to four months. In singular cases leukopenia as low as 2,400 to 2,515 with a normal red blood cell count and undisturbed differential count was seen, lasting five years after the completion of the radiation therapy. Leukopenia lasting six to seven months after therapy is not infrequent. In the majority, the restitution of the white blood cell count has taken place in four to eight weeks.

In high voltage therapy in which the volume doses were smaller, the leukopenic reaction was less than in conventional therapy.

The differentiation of cell types in 30 cases showed the following changes: a decreased count was shown by the stabs in 88 per cent, segmented in 45 per cent, eosinophils in 15 per cent, lymphocytes in 100 per cent, and monocytes in 19 per cent; the basophils showed an absolute increase in 11 per cent and a relative increase in 27 per cent of cases. Generally, the lymphopenia goes along with increase in gamma

globulin values. The shift to the left was never seen. The increase in basophils (mast cells) and monocytes is seen also in allergic phenomena and the increase in monocytes appears to be a good prognostic sign.

The erythrocytes and the hemoglobin values did not show any essential change as a result of radiation therapy. Thrombocytopenias were described elsewhere. In 2 cases with leukopenia of 1,540 and 1,380, sternal marrow punctures were performed. One of these showed inhibition of erythropoiesis and the other slight increase in reticular elements. A case of "auto-aggression" is described in a twenty-six year old woman who was treated because of malignant lymphoma. She previously received blood transfusions with M instead of N and Rh positive instead of Rh negative blood. Radiation therapy led to autohemolysis which responded well to ACTH.

The incurred infections during the radiation therapy such as pneumonias, cystitis, pyodermias, either prevent or improve the radiation leukopenia. The abscess formation and breakdown of tumors act in a similar manner.

Treatment of leukopenia: Protraction of the irradiation lessens the leukopenia; therefore, the radiation rhythm should be governed by the blood cell count. No effect was seen from vitamin C or B complex. The author does not have personal experience with B_{12}. Hormone therapy has no effect. ACTH and prednison have a normalizing effect which lasts seven to fourteen days and encompasses not only the granulocytopoiesis, but also the lymphocytopoiesis. The blood transfusions have no effect on granulocytopenias, but very favorable effect was noted from autoblood injections. Five ml. of venous blood injected intramuscularly (Sakurai) raised the leukocyte level to 130–180 per cent from the initial value in twelve hours. The author has 33 such cases on his list. Injection of 5 ml. of plasma has no leukocyte-stimulating effect. The addition of hyaluronidase to autoblood injections increases the leukocytic effect (Sakurai). The leukocytic reaction lasts for a shorter period than the one produced by treatment with ACTH. The granulocyte increase is prolonged and more pronounced than that of the lymphocytes.—*Nathan Kriss, M.D.*

Widmann, H. Die Reaktionen der Leukopoese nach fraktionierter kurzzeitiger Ganzkörperbestrahlung. (The reaction of leukopoiesis after fractionated short-term whole body irradiation.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Jan., 1958, *88*, 25–31. (From: Medizinische Klinik und Poliklinik and Medizinisches Strahleninistitut der Universität, Tübingen, Germany.)

Three groups of female mice received 50 r on the first, fourth, seventh, tenth, and fourteenth days using the following factors: 180 kv., 10 ma., ½ mm. Cu, 40 cm. target skin distance and 24×30 cm. cone. On the seventeenth day of the experiment, the three groups of 10 animals each were injected subcutaneously with one of the following drugs: first group, 5 mg./kg. colchicin; second group, 2 mg./kg. naphthochinon; and third group, 10 mg./kg. chelidoxanthin. A control group of 10 animals received only irradiation without drugs, and an additional group of 10 animals received the drugs only, without irradiation.

It was found that colchicin did not change the leukopenic phase of irradiation and did not produce a leukocytic reaction as seen on control animals (nonirradiated). The naphthochinon leukocytosis appeared in the irradiated animals in a markedly attenuated form. The changes in blood picture in radiation-exposed animals under the influence of colchicin and naphthochinon were similar to a great extent to those which were produced by blockade of the sympathetic system (dibenamin). Special attention was paid to the changes in the blood picture following chelidoxanthin which produced a marked granulocytic reaction in spite of exposure to substantial radiation.

The irradiation does not influence the action of the test substances in uniform manner. The active substances preserve their different ways of action also in the animals damaged by irradiation.—*Nathan Kriss, M.D.*

Kaplan, Henry S. Radiation research and the future of radiotherapy. *Radiology*, Dec., 1957, *69*, 801–808. (Address: Stanford University Hospitals, 2361 Clay St., San Francisco 15, Calif.)

The author discusses present trends in radiology and enumerates some of the problems which confront American radiologists. The role of research in radiation therapy is stressed.

Cancer is a biologic problem and its destruction by radiation is a biologic response. The disease and its treatment must therefore be comprehended in biologic terms. Training in radiobiology must be an important part of our training and accreditation programs in radiation therapy.

Research in radiobiology has led to important discoveries in the past decade, but many problems remain to be solved. The field of cell physiology, the enzyme systems and the nucleic acids need further investigation. Studies of the relative biologic efficiency of roentgen and gamma rays and other forms of ionizing radiation may also contribute to our understanding of the comparative importance of various primary radiochemical reactions in biologic damage. The possibility that combinations of selected chemotherapeutic agents and irradiation may act synergistically in the control of cancer, deserves further study. Through biologic research it may be possible to effect major improvements in present cure rates. By a concerted effort to re-orient both our

training and our research in this direction, we may be able to create a new generation of radiation therapists trained to apply experimental methods to the revitalization of their chosen field.—*Arno W. Sommer, M.D.*

RADIOISOTOPES

CASSIDY, CARL E., and VANDERLAAN, W. P. Laboratory aids to diagnosis in thyroid disease. *New England J. Med.*, April 24, 1958, *258*, 828–831. (From: The Ziskind Research Laboratories, New England Center Hospital-Pratt Diagnostic Clinic, and the Department of Medicine, Tufts University School of Medicine, Boston, and the Scripps Clinic and Research Foundation, La Jolla, Calif.)

Thyroid I^{131} uptake studies and serum protein bound determinations are now commonly used tests of thyroid function. The thyroid suppression test, the total serum iodine determination and thyrotropin injections to stimulate a responsive thyroid gland are supplementary tests which may unravel a clinically atypical case of thyroid disease.

There are several factors that may alter the I^{131} uptake studies and also the serum protein bound iodine determinations in euthyroid patients. The I^{131} uptake may be high in euthyroids in simple goiter, congestive heart failure, renal disease or hepatic insufficiency; patients who have recently discontinued antithyroid drugs, thyroid, thyroxine or tri-iodothyronine; and in patients who have had a thyroidectomy or treatment with I^{131}. The I^{131} uptake may be low in euthyroids who have received iodine in any form; in those taking thyroid, thyroxine or tri-iodothyronine; and in some cases of thyroiditis, renal disease or anterior pituitary failure. Those taking cortisone and ACTH may have low I^{131} uptakes. The serum protein bound iodine determinations may be high in euthyroid patients who have received iodine containing radiopaque media for roentgen studies or who have taken inorganic iodides or thyroid in excess of 180 mg. daily or have taken effective replacement doses of thyroxine. The protein bound iodine may be elevated in acute or subacute thyroiditis or in early stages of hepatitis. It is normally elevated in pregnancy. Low protein bound iodine determinations may be found in euthyroid patients who have received cortisone or ACTH, or recent injections of drugs containing mercury and in some cases of cirrhosis and nephrosis or other conditions associated with hypoalbuminemia. Tri-iodothyronine ingestion and anterior pituitary failure may also depress the protein bound iodine formation.

The thyroid suppression test is used when the diagnosis of hyperthyroidism is in doubt. Thyroid U.S.P. in a dose of 180 mg. is given for twenty-one days and the I^{131} uptake study is then repeated. The uptake of I^{131} is depressed below normal in the euthyroid patients, but not in the hyperthyroid patients. It is not depressed in some cases of simple goiter.

The total serum iodine determination in conjunction with the protein bound iodine determination was found to be quite useful in that the difference between the two or the unbound iodine was never more than 2 μg., unless the patient had received exogenous iodine.

The thyrotropin injection test is used to determine whether or not a responsive thyroid gland is present. The thyrotropin is injected intramuscularly and in eighteen hours an I^{131} uptake study is done.

Twelve problem cases are presented in which the 3 supplementary tests and also the knowledge of the variations from normal listed above were used to clarify the thyroid status.—*Charles W. Cooley, M.D.*

DOERING, PAUL, and KRAMER, KARL. Die Bestimmung des Schilddrüsengewichtes mit der Szintigraphie nach Gabe von Radiojod; Ein Beitrag zur Dosierung des Radioisotopes. (Determination of weight of the thyroid gland by scintigraphy after administration of radioactive iodine: A contribution to radioisotope dosage.) *Strahlentherapie*, Feb., 1958, *105*, 245–259. (From: Medizinische Universitätsklinik, Göttingen, Germany.)

Scintigraphy with adequate lead collimation can accurately establish the frontal area of the thyroid gland after administration of radioactive iodine. The frontal area and weight of thyroids in 51 cadavers were related as

$$\text{Weight} = 0.326 \cdot \sqrt{A^3}$$

with a maximum spread of differences of 25.6 per cent or 8.2 grams.

The authors point out that the value of more accurate estimation of the weight of the thyroid gland is considerably decreased by such other factors as the nonhomogeneous distribution of radioiodine in the thyroid and the varying radiation sensitivity of thyroid cells.—*Henry G. Moehring, M.D.*

CHEARS, W. CROCKETT, JR., MCCRAW, BURLEY H., TYOR, MALCOLM P., and RUFFIN, JULIAN M. The I^{131} labeled triolein absorption test: Reproducibility and factors affecting blood levels. *South. M. J.*, April, 1958, *51*, 433–437. (From: The Department of Medicine, Duke University Medical Center and Veterans Administration Hospital, and the Radioisotope Service, Veterans Administration Hospital, Durham, N. C.)

Diseases of the small bowel, pancreatic insufficiency, acholic states and some cases following vagotomy or partial gastric resection may show the mal-

absorption syndrome. The study of the absorption of fat may be very important in the evaluation of the above diseases. There have been several tests to determine fat absorption. The tests are based on the amount of fat in the stool and/or the amount of fat in the blood following the ingestion of a test meal. Several older methods such as examining the stool grossly and microscopically for fat particles or observing the blood fat following a test meal or doing a chylomicron count are still important. Recently the I^{131} labeled triolein test as a measure of fat absorption has been quite widely accepted. The authors studied the test to evaluate the errors inherent in the method, the reproducibility of the results, the effects of variations in the dosage of triolein or the emulsion, the effect of extremes in body weights, the effect of delayed gastric emptying and whether the radioactivity of the blood or of the stool is the most important clinically.

The test meal consisted of an emulsion containing 50 per cent peanut oil in water and containing 50 μc of I^{131}-labeled triolein per 100 ml.; 4 ml. of "Tween 80" was used per 100 ml. to emulsify it and 1 ml. of Lugol's solution and 20 gm. of barium sulfate were added. Forty ml. per square meter of body surface was given. The I^{131} triolein bond is stable for periods up to a week.

Sixty-eight normal and 41 clinically abnormal patients were tested. The test was found to be reproducible in normal subjects. The variation in dosage of I^{131} labeled triolein from 15 to 53 μc and in the dosage of the total emulsion did not significantly affect the blood or fecal values. Extremes of body weight and moderate delay in gastric emptying were not accompanied by abnormal values. The errors inherent in the I^{131} labeled triolein test are largely those which are common to all laboratory procedures utilizing radioisotopes.

The range of deviation of the blood values in normals was small. Blood values were considered abnormal if the peak values were less than 2.2 per cent of the administered dose per liter. The 4th, 5th and 6th hour blood samples were found to be sufficient for the test. Fecal radioactivity over 5 per cent of the administered dose was considered abnormal. The fecal radioactivity was thought to be more reliable than the blood values as an index of impaired absorption providing all the stools were properly collected. The blood studies were found to be more useful clinically as the results could be known in hours rather than days. Both studies, however, should be done if possible.

The I^{131} labeled triolein test is one of the most useful available tests of fat absorption.—*Charles W. Cooley, M.D.*

Schumacher, Werner, and v. Oldershausen, Hans-Felch. Die Leberfunktionsprüfung mit J^{131}-markiertem Bengalrosa. (Hepatic function test with I^{131} tagged rose bengal.) *Strahlentherapie*, March, 1958, *105*, 430–440. (From: Röntgen- und Strahleninstitut und II. Med. (Infekt.-) Abt. des Rudolf Virchow-Krankenhauses, Berlin, Germany.)

This study of measurements of radioactivity over the hepatic and biliary regions in 15 patients with normal livers and in 60 patients with hepatic or biliary tract disease, all of whom had received 0.5 μc /kg. of I^{131} tagged rose bengal by vein showed that:

The level of radioactivity over the liver in the first two to three minutes after the injection yielded a rough measure of hepatic blood flow.

The level of radioactivity over the liver in the first two to fifteen minutes reflected the functional condition of the hepatic parenchymal cells.

The follow-up measurements in the same patient gave a good progress study of viral hepatitis.

This sort of hepatic function test was worthwhile in subicteric state, acute or chronic hepatitis and in hepatic cirrhosis.

Normally radioactivity over the gallbladder rises five to ten minutes after the injection and reaches a maximum in twenty to thirty minutes.

The twenty-four hour urinary excretion of rose bengal normally does not exceed 5 per cent.

In selected patients, scintigrams of the right upper quadrant, thirty and ninety minutes after the injection may yield information about localized hepatic regions which are nonfunctioning and thus permit aimed liver puncture for biopsy, or accurately directed external radiation therapy.—*Henry G. Moehring, M.D.*

von Harnack, G.-A., Horst, W., Lenz, W., and Zukschwerdt, L. Homotransplantation von Schilddrüsengewebe bei einem eineiigen Zwillingspaar. (Homotransplantation of thyroid tissue between uni-ovular twins.) *Deutsche med. Wchnschr.*, April 4, 1958, *83*, 549–555. (From: Kinderklinik, Strahleninstitut und Chirurgische Klinik des Universitätskrankenhauses, Hamburg-Eppendorf, Germany.)

Following a maternal episode of hyperthyroidism during gestation, slightly underdeveloped uni-ovular female twins were delivered. Soon after birth, one of the sisters developed severe hypothyroidism, while the other revealed no abnormalities in physical growth, nor otherwise, and the latter's I^{131} uptake was 17 per cent after two hours and 47 per cent after forty-eight hours. In the former, there was a 0.8 per cent uptake after two hours, none after forty-eight hours.

Replacement therapy with thyroid hormone in the practically athyroid twin succeeded to produce average growth and development, by comparison with her sister. It was then decided to transplant thyroid tissue from the healthy twin, and this was accom-

plished in 1956, when they had reached the age of seven and one-half years. Subtotal resection of the left thyroid lobe was performed and, after histologic examination, the portion of organ was "implanted" to both sides of the trachea in the other twin.

There were no discernible ill aftereffects in the donor. In the first weeks after surgery, the receiver required no replacement therapy, but later she showed again signs of hypothyroidism, and daily doses of 0.05 gm. of desiccated thyroid (as against 0.075 gm. prior to operation) were necessary to maintain an euthyroid state. About one year later, I^{131} uptake in the receiver had risen to 19 per cent after twenty-four hours.

The authors express the hope that the implant (which must have "taken") might possibly grow in the future and some day provide all the necessary hormone for the formerly athyroid twin.—*E. R. N. Grigg, M.D.*

JOHNSON, P. C., BIRD, R. M., and SMITH, C. W. Liver counting of cobalt-60 labeled vitamin B-12 in the diagnosis of pernicious anemia. *South. M. J.*, April, 1958, *51*, 417–420. (From: The Radioisotope Service, VA Hospital, and Department of Medicine, University of Oklahoma School of Medicine, Oklahoma City, Okla.)

The diagnosis of an untreated case of pernicious anemia can be simple, since achlorhydria, megaloblastic bone marrow and a good reticulocyte response to vitamin B_{12} therapy are generally present. In these cases there is no need to use the cobalt 60 vitamin B_{12} absorption test.

The cobalt 60 vitamin B_{12} absorption test is superior to the other tests in that it is not influenced by prior treatment, therapy need not be withheld prior to a positive diagnosis and it can separate the megaloblastic anemias due to malabsorption syndromes and dietary insufficiency from pernicious anemia. It is also of value in patients with progressive neurologic disease but with little or no anemia.

The fundamental defect in patients with pernicious anemia is a deficiency or absence of the intrinsic factor which accounts for the failure of absorption of vitamin B_{12} from food. The efficiency of intestinal absorption of vitamin B_{12} can be estimated by feeding cobalt 60 labeled vitamin B_{12} and measuring the amount recovered in the stool or in the urine after an intramuscular loading dose of the stable vitamin B_{12}. To separate the patients with pernicious anemia from those with malabsorption syndrome, the test is repeated and whole dialyzed human gastric juice is given with the repeat dose. An increased uptake is noted in all patients with pernicious anemia and not in the cases of malabsorption syndrome.

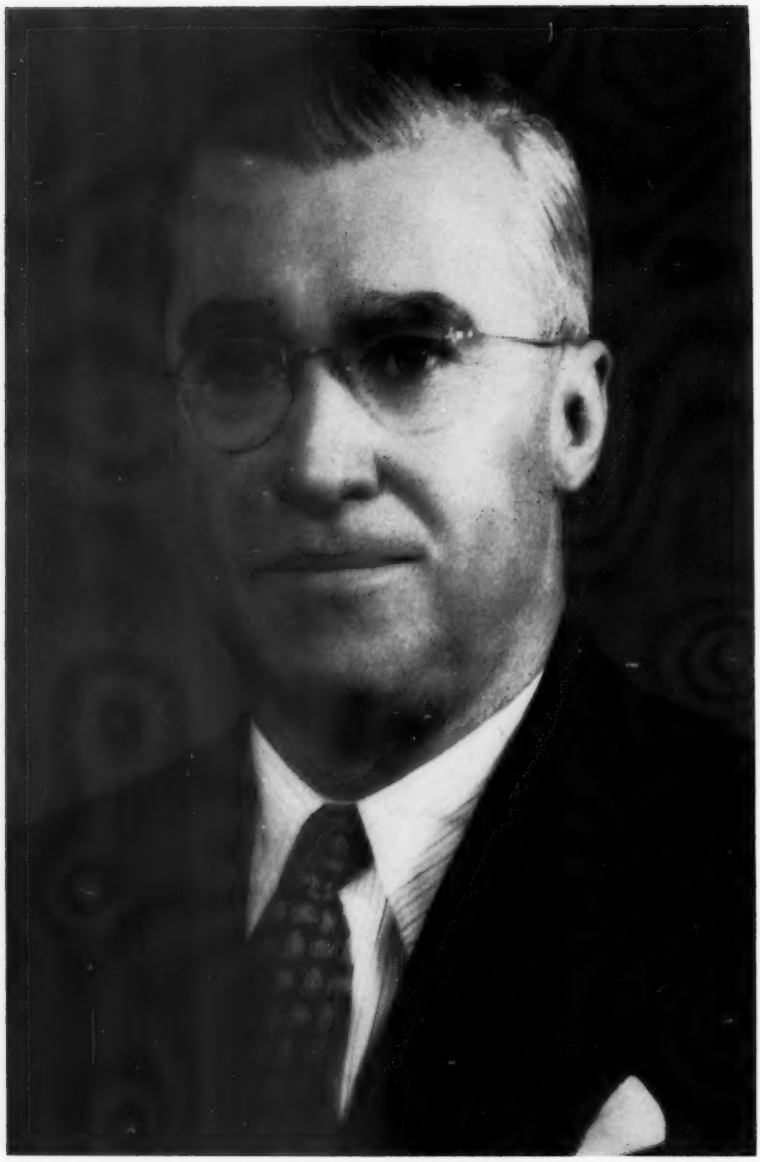
The authors have used a 5 inch scintillation detector to count the activity in the liver and found that the mean normal concentration in the liver was 11 per cent and in the pernicious anemia cases 1.5 per cent. The liver count is made one week after the ingestion of the cobalt 60 labeled vitamin B_{12}. The advantage of this test is that no urine or stool collections are needed. The large 5 inch detector overcomes the technical difficulty posed by the smaller detectors in that it covers and counts a large portion of the liver. The absolute value of radioactivity is not represented by the count due to the variable size of the liver and the panniculus.—*Charles W. Cooley, M.D.*

MATTHES, THEODOR, and KRIEGEL, HEINRICH. Über die Speicherung von Thoriumdioxyd in den Keimdrüsen von Kaninchen und beim Menschen; (Eine autoradiographische Studie). (Deposition of thorium dioxide in the gonads of rabbits and human; [an autoradiographic study].) *Strahlentherapie*, March, 1958, *105*, 441–449. (From: Deutsche Akademie der Wissenschaften zu Berlin, Institut für Medizin und Biologie, Berlin-Buch, Arbeitsbereich Geschwulstklinik und Arbeitsbereich Biologische Krebsforschung, Berlin, Germany.)

A year and a half after the intravenous injection of thorotrast the gonads of 9 rabbits were examined histologically and autoradiographically. The testes showed fine, wide scattering of radioactive substance in the connective tissue between testicular segments. The ovaries showed a heavier deposition in the stroma in the follicle and region of the theca of the follicle. Even coarser accumulations appeared in the atretic follicles.

The ovaries of a patient who died of thorium-induced hepatic carcinoma showed alpha radioactivity in the stroma and the corpora candicantia. This patient received thorotrast at the age of twenty-nine years. Thereafter she menstruated normally for five years, but had had 9 spontaneous abortions. Then she developed oligomenorrhea and never again became pregnant despite no change in her sexual life and a continued desire to bear children. She died at the age of fifty-two.

Though the amount of thorium in the gonads is small, particularly in the testes, relative to the amount deposited in the liver, the authors point out that alpha radioactivity in such close contact with germ cells must carry high hazard of genetic damage.—*Henry G. Moehring, M.D.*



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